Delta Technology

All About Screening

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Introduction

This manual is designed to help the user become familiar with the subject of screening and provides some tips and tricks for dealing with PostScript imagesetters.

Nowadays, there are so many different screening methods which suit certain applications particularly well, for example:

- Diamond Screening

  and

- Megadot

Diamond Screening is a frequency-modulated screen and gives you a high level of detail in offset printing which so far was unattainable. A reproduction which comes close to a photograph is now possible. For more details about Diamond Screening, refer to *Diamond Screening* on page 7–21.

With the new Megadot screen, a smoothness in the overprint which was considered impossible can now be attained. At the same time, the high level of detail has improved as “offset rosettes” no longer exist. Furthermore, working with this screen is simple and uncomplicated. It is, in fact, almost the ideal screening method. For more details about the Megadot screen, refer to *Megadot Screen* on page 7–27.

About this Manual

The first chapters talk generally about

- laser imagesetters,
- laser and screen dots,
- printing methods

  and
- screening.

The subsequent chapters will describe

- screening methods,
- screen dot shapes (with examples)

  and
- screen systems (with examples).

Requirements

Since this manual is aimed at a very broad spectrum of readers, practically no previous knowledge of screening is required.

Furthermore, mathematic formulas have been kept to a minimum to make easy reading. They have been used only in those cases where it is absolutely necessary.

Reading this manual does not transform the reader into a trained repro person. This manual also has some interesting notes for experienced users.

Translation List Old --> New Screen Names

Old Name	New Name
RT01 HELL	RT Classic
RT04 HELL	RT Y45° K fine
I.S.10 KONV	IS Classic
I.S.20 K60	IS Y60°
I.S 26 K30	IS Y30°
I.S.30 K7.5	IS CMYK+7.5°
RT01_GRAV	RT Classic Gravure
RT04_GRAV	RT Y45° K fine Gravure
IS_10_GRAV	IS Classic Gravure
IS_20_GRAV	IS Y60° Gravure
IS_26_GRAV	IS Y30° Gravure
IS_30_GRAV	IS CMYK+7.5° Gravure
Diamond Screening	Diamond
HELL08_elliptical	Elliptical
HELL01_Round-square	Round-Square
HELL06_Round	Round
HELL03_GRAVURE	Pincushion
HELL04_GRAVURE	Square

Laser Imagesetters

This chapter will describe the structure and principal properties of some recorder types and their use.

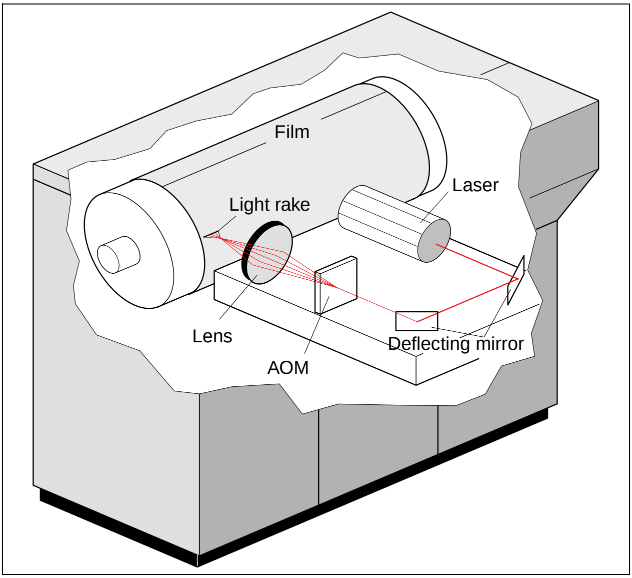
Out-drum Imagesetters

Out-drum imagesetters such as those of the DC 3000 series are traditionally used in the repro sector for high-quality color work.
With these recorders, the film to be exposed is mounted on the outside of a drum. While the drum is rotating, the film is exposed using a laser head which moves along the drum very accurately by means of a spindle.
In this laser head, the laser beam is split up evenly and modulated by an acousto-optical modulator (AOM) to a “light rake” with preferably 8 or 12 laser beams.
These laser beams are then projected onto the film by means of a zoom lens system.
Every laser line width and, consequently, every recorder resolution can be set, provided that this is possible with the zoom lens system and feed.

These recorders must be very stable due to the relatively large forces in motion and the unbalanced state created by a film mounted on a drum.

Another point which is really only understood when you are more familiar with screening is the interferences which are possible between the screen and the light rake. For this reason, screen dots are mainly constructed from an integral multiple of the light rake. Furthermore, the zoom value must be set very accurately.

Diagram of an out-drum imagesetter:



With out-drum imagesetters, a very high quality can be produced even at a moderate speed.
Of course, the full potential of speed and how to increase it has not yet been exhausted.
A laser diode sensor enables a light rake with a great number of laser lines to be produced so that a very broad strip can be exposed per revolution.
Recorders with a diode array are making a comeback at present, for example, Trendsetter, the plate imagesetter.

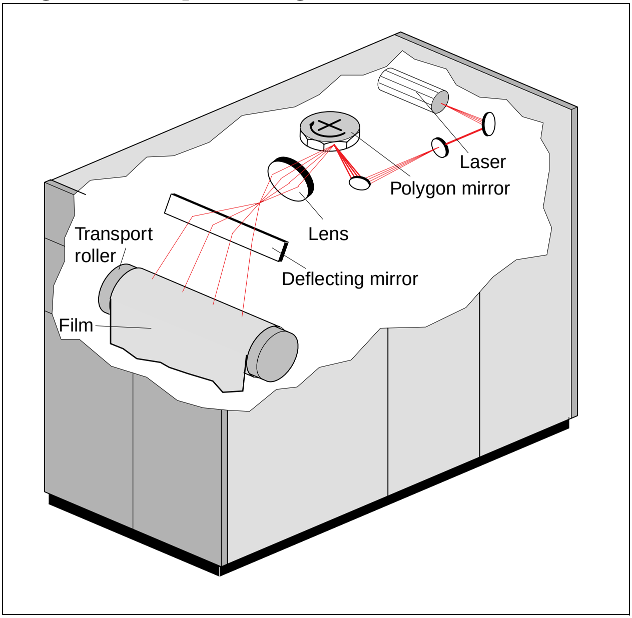
Flatbed Imagesetters/Capstan Imagesetters

Flatbed or capstan imagesetters were mainly used in typesetting. With these types of imagesetter, the film to be exposed was mounted on a flat surface or moved slowly over a drum respectively.

A fast rotating polygon mirror or an oscillating mirror was used to deflect the laser beam cross-wise to the feed direction of the conveyor bed or drum. The beam was then projected onto the film by means of a large lens (scanner lens).

With capstan imagesetters, film strips of "any" length can be exposed. However, special know-how is required to achieve a sufficiently precise film transport.

Diagram of a capstan imagesetter:



Due to the long optical distances, some recorders are built with vibration reducing materials such as plastic concrete and are placed on vibration absorbers. This protects the laser beam from being deflected by ambient vibrations and prevents exposure from being subject to errors. Corrections to the scanner lens are complicated since the reproduction lengths are noticeably different in the middle and at the edge of the film and the reproduction must have the same sharpness everywhere.

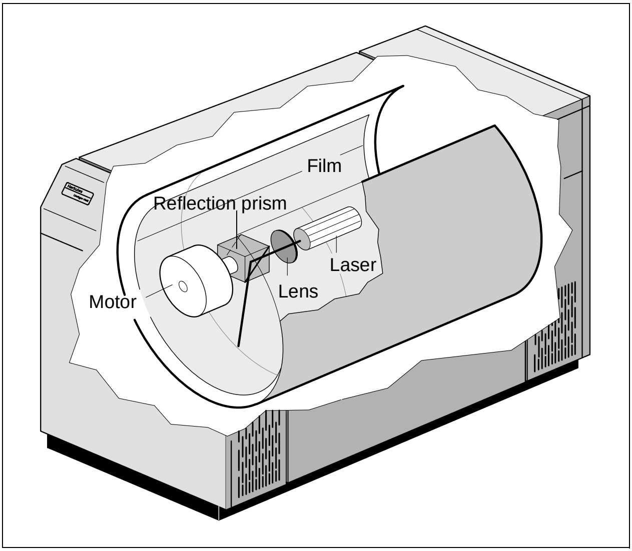
As pyramidal errors cannot be excluded in a polygon, interferences between the screen and the polygon occur in these imagesetters as well.

Moderate quality coupled with very high speed can be achieved with this type of recorder.

In-drum Imagesetters

In-drum imagesetters are used both for typesetting and for repro work. With these recorders, the film to be exposed runs along the inside of a partially open hollow cylinder. The laser moves precisely along the center. The laser beam is deflected by means of a lens and fast rotating prism and projected onto the film.

Diagram of an in-drum imagesetter:

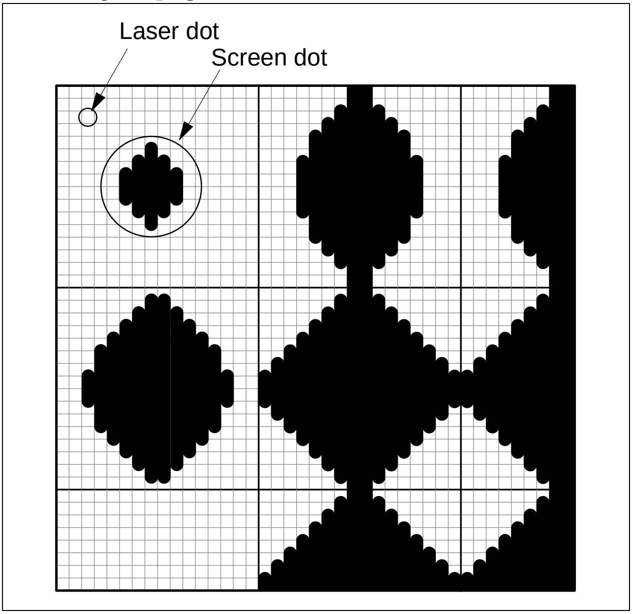


The optical distances are noticeably shorter here than in the flatbed imagesetters and vibration absorbers do not play such a great role. The optics is also more simple since the reproduction length is always constant.

With this type of recorder, top quality can be attained for repro work, at high speeds and a moderate price. This imagesetter has become successful on the market. Herkules PRO and Signasetter of Heidelberger Druckmaschinen AG are examples of this type of imagesetter. Modern plate imagesetters, such as the Gutenberg, are also built on the same principle.

Laser Dots and Screen Dots

All laser imagesetters work on the principle of one laser beam (or several together) moving line by line over the film.
At the points where the film is exposed, the laser beam is switched on. Otherwise, it is switched off. The laser beam is switched digitally in a precisely defined clocking scheme as is shown in the sketch below.
Each laser dot which can be switched is known as a pixel (picture element).
Each screen dot is made up of a certain number of pixels. In this way, a screen is created into the dot matrix of the recorder.
More details can be found in *General Information about Screening* on page 4–3.

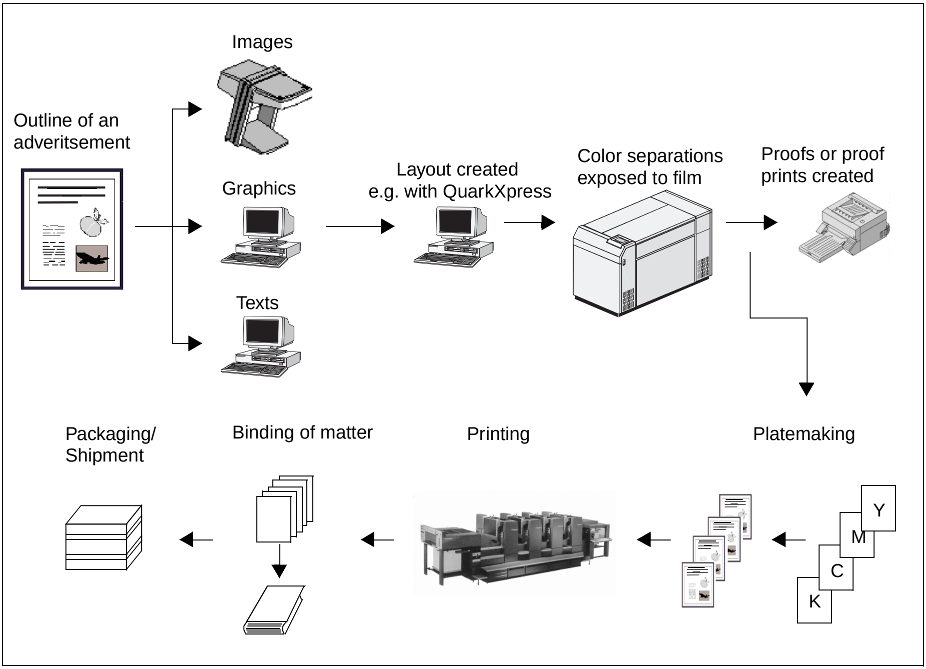


Practical Aspects of Printing

Before we turn our attention to screening itself, let us briefly look at this chapter where aspects such as dot gain in printing, gradation curves etc. will be described and in what way they ought to be taken into account when creating a repro. This subject is vast and as a result it is not possible to explain all aspects of printing within the framework of this book.

To start with, it is important to visualize once the entire process involved in producing printed matter, starting with the design and ending with the finished product.

Production of printed matter:



You start off with the plan and design of the matter you wish to print. The next step is the production of the printing originals. To obtain these, the images required are scanned, texts set, graphics created, retouched and assembled with a page layout program to form pages which are ready for printing. The finished pages can then be exposed on an imagesetter (e.g. Herkules PRO), and proofs or proof prints can be made. At the printer's, the various pages are assembled to signatures and copied to printing plates. Bookbinding follows on the printing process, where the pages are folded, bound and trimmed. The finished product is now packed and dispatched.

This was just a brief summary of the traditional steps in the process. For our purposes, it is not necessary to go into detail about more modern processes such as direct exposure of the printing plates or direct printing since basically it is only a question of steps in the process being left out and the printers being supplied with data carriers.

The steps which follow the creation of the finished color separation films require some preparation which must be taken into account when the films are being created.

Platemaking

To keep the description simple, we will only look at the copy for a positive offset plate.

The printing plate consists of an aluminium carrier sheet with a light-sensitive plastic-laminated coating. Exposure with UV light breaks up the chemical bonds so that the exposed parts can be washed out.
The olephile plastic-laminated coating absorbs the oily ink while the hydrophile aluminium carrier sheet in the printing press is covered with a dampening solution so that it cannot absorb any ink.

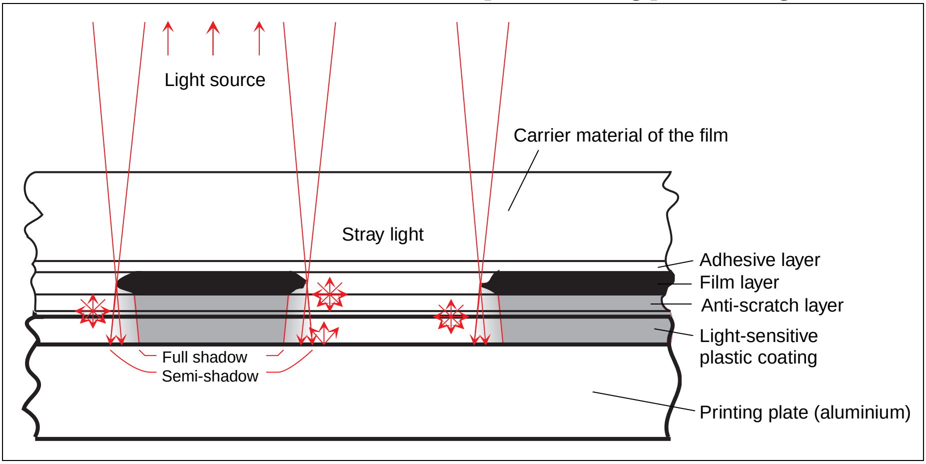
Any overexposure or underexposure when copying the films to the printing plate affects the ink coverage.

In many films, the edges of the screen dots are not absolutely sharp, there is a gray area here.
The effects of overexposure can be seen even in extremely hard dot films with a sharp edge since the layer of film is always a fraction away from the plate and is itself approx. 1μ thick.
Reflections on the metal carrier sheet and stray light also play a role in this respect.

Generally, you try to cover up the cutting lines of films. Overexposure which has just been mentioned is used to achieve this and, in some cases, a diffusion film as well. The dots are often more pointed when copied.

Some special aspects must be remembered when working with Diamond Screening. Refer to *Diamond Screening* on page 7–21.

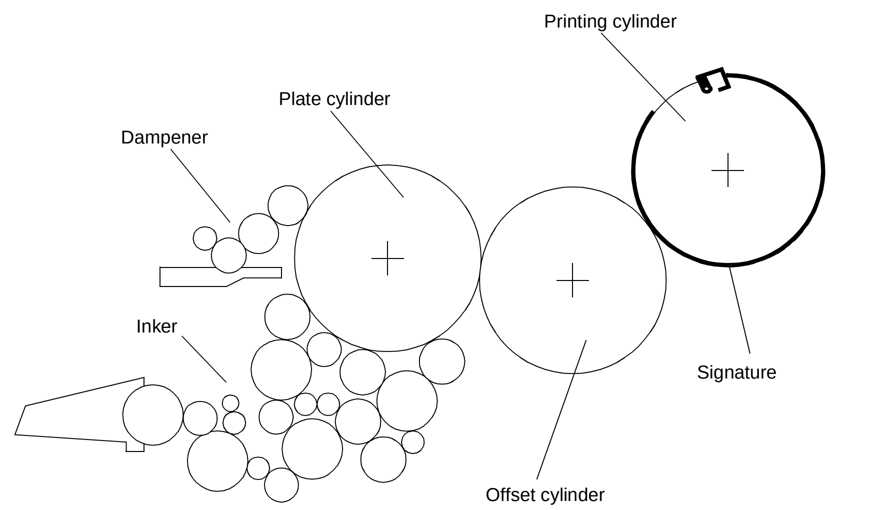
Effects of overexposure during platemaking



Dot Gain in Printing

The most important effect which has to be considered when producing a litho is dot gain in printing. This effect will now be explained briefly using offset printing as an example.

Sketch of an offset printing press:

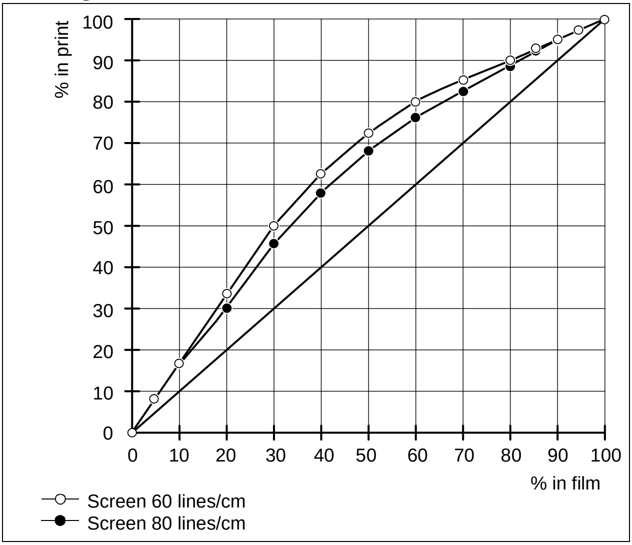


Ink is transferred to the plate cylinder by an inker and dampening solution by a dampener. The ink is transferred from the plate cylinder to the offset cylinder and only then is it printed onto the stock. It is easy to deduce that the printing dots (or pixels) are flattened during these transfer operations.

The resulting dot gain in printing can be influenced by many factors such as the amount of ink, the ink-water ratio and the pressure exerted by the cylinders.

The printing characteristic is determined by mapping the ink coverage obtained in print above the ink coverage in the film
There is a noticeable dot gain in the midtone. There can be relatively large differences in dot gain, depending on your printing press, printing conditions, type of paper used and screen frequency.
Process calibration is usually necessary if one of these factors is changed.

Printing characteristic:



When the repro is being created, a standard dot gain is already taken into account in the color gradation. The process calibration tool makes it easy to adapt this dot gain to the printing characteristic at hand.

Process Calibration

Process calibration is simple using the *Output Manager Utility* program. It is described in detail in the *Output Manager Utility - User's Guide*. You only have to expose the gray scales with the relevant density levels, make a proof print and measure them.

In the Process Calibration dialog box, the values are entered in the table in the "Nominal", "Process" and "Is" columns.
The program then calculates the correction tables so that the printing results are usually immediately correct.
The ink coverage of the film is entered in the "Nominal" column, the ink coverage to result in the printing process is entered in the "Process" column and the "Is" column shows the ink coverage actually obtained during the printing process which will be calibrated.

It is advisable to also enter values for the following density levels: 2%, 7%, 93%, 97%, 98% and 99% .

In most cases, process calibration is the same for all colors, at least within the measuring tolerance.
Process calibration varies according to color for screen systems RT Y45° K fine and Megadot (refer to *Screen Systems* on page 7–3) due to the very different screen frequencies in the color separations.
Process calibration for the other screen systems can also be performed separately for each color, in particular if there is a great difference in the screen frequency. In this case, the differences should be corrected preferably in the image editing program or even during scanning.
Process calibration which can be performed separately for each color is possible in the more recent versions of the Delta RIP.

Proofs

In the printing industry, there is an interplay of many processes and, very frequently, different companies. As a result, it is important to ensure that the results desired are actually obtained.

There are many different proofing methods:

- from a simple output on a laser printer
- to a proof print.

Very different aspects are evaluated, depending on the proofing method you choose. In the table below, different proofing methods, each with their own characteristics, are described.

Proofing Method	Costs	Color Fidelity	What Is Examined
Laser printer black-and-white	#	No color, but single separations are possible	Text, fonts, print test elements, presence of all images and graphics, register and trimming marks, data
Blueprints	#	As above	As above, plus: imposition scheme
Color laser printer, color ink jet printer	##	Not very accurate, colors can be reproduced to a certain extent, no screens	As above, plus: inking, no imposition scheme
Thermo-sublimation printer	###	Colors can be reproduced well, no screens	As above, plus: (coarse) inking (depends on color management)
High-end proofs (digital) e.g. 3M Digital Matchprint	####	Very good, colors can be reproduced very well, original screens	As above, plus: color balance, gray balance moiré effects imposition scheme also possible

Proofing Method	Costs	Color Fidelity	What Is Examined
Cromalin	####	Very good, colors can be reproduced very well (with toner), original screens	As above, plus: films, register, imposition scheme also possible
Laminate proofs (3M, Fuji)	####	Very good, colors can be reproduced very well, original screens	As above, plus: register inaccurate, imposition scheme also possible
Proof print	#####	Very good, colors can be reproduced very well, original screens	As above, plus: exact register, imposition scheme

Thermo-sublimation Printers and High-end Proofs

With thermo-sublimation printers and high-end proofs it is possible to come very close to reproducing the printed result if the color transformation tables are determined carefully and good color management is used. Theoretically, this would also be possible with a more simple method if the devices were able to produce consistent colors.

Cromalin and Laminate Proofs

Cromalin and laminate proofs give you little scope for changing the printing characteristic and adapting it to special ones. Only proofs for a standard printing characteristic can be produced. This is both an advantage and disadvantage since the proofs produce very consistent colors.

Print Proofs

The print proof gives the user great scope for varying, the reproduction of color. As a result, it is possible to adapt the reproduction to various printing characteristics in the production run. However, the printer frequently does not know whether the good result of the proof print can be reproduced at all or reliably on the production press.

Other Aspects

As early as the planning stage, you should find out about the colors which can be reproduced in printing. It is obvious that silvers or golds cannot be produced by the four process colors C, M, Y, K but that spot colors are required for them.
For example, if the color location of a relatively simple-looking blue is measured, it can be seen that it lies way outside the printable area. This may surprise you. Naturally, this color change depends on the customer requirements, on whether the customer really wants a spot color (e.g. Nivea blue).

Some aspects should not be forgotten in passing:

- The register marks, trimming marks and print control elements should be agreed upon with the printer and positioned correctly.
- If images or graphic elements are cut, trapping is required to compensate the tolerances when the product is trimmed.

Depending on the product supplied (data carrier, signature or single sheet of film), some other aspects should be taken into account. These will be briefly touched upon here:

- If data carriers are to be supplied, the first thing to clarify is which data carriers and which data formats can be read. You should also check that the various versions are compatible, especially if post-editing might be required. Furthermore, you should also make sure that all images, graphics and fonts used are in the correct folders. To avoid inflating the amount of data, only the data really required should be supplied.

- Supplying films for a signature saves the printer the time-consuming task of mounting the single pages onto a signature. If a film is to be supplied, you should find out what imposition scheme is planned, also the what type of bookbinding will be used. For example, for thread sewing, the pile of double pages are sewn together by a thread in the middle. The outer pages shift inwards due to the thickness of the pile. This can be counteracted by positioning the pages accordingly on the signature.
- If single sheets are to be supplied, the repro person does not have to be concerned about much as the printer is entirely responsible for the correct mounting to produce signatures.

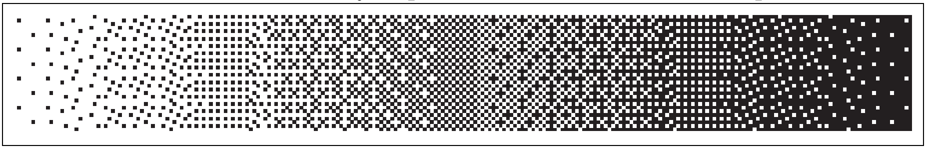
General Information about Screening

Why Do We Use Screens?

This question seems a bit superfluous at first because every laser printer can print images.
However, laser printers cannot depict gray tones. A laser dot can only be black or remain white.
Different gray tones are simulated by printing varying amounts of laser dots per area. Normally, dither screens are used in printers.

Dither Screens

Dither screens distribute the various laser dots mainly according to a set pattern so that they are distributed as evenly as possible as is seen in the example below.



Another method possible is to use error diffusions.
In this method, deviations from the density desired are taken into account.

These deviations occur:

- because only black dots can be set and gray tones cannot be added up on a small area,
- when deciding whether a laser dot is to be visible or not.

During platemaking you can already see that these images are considerably darker and are not really suitable for further processing.
The laser dots are not distributed well and a long fringe line between the black and white elements appears.
As described in Chapter 3, *Practical Aspects of Printing*, errors occur mainly at the edges of the screen dots when copying the films to the printing plate and due to the dot gain in printing. For this reason, the screen dots should be created as compactly as possible to keep the fringe line to a minimum.

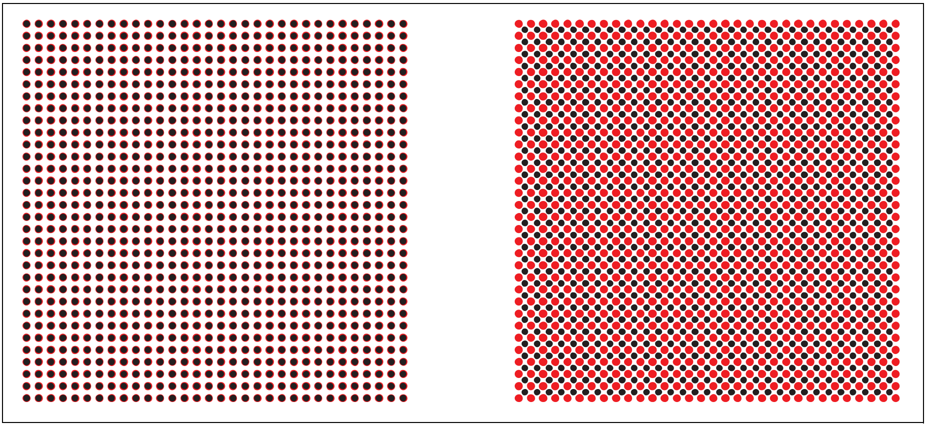
Color Shift

Before turning our attention to the screening methods, let us look at two effects which you should be aware of.

One of these effects is color shift.

Color shift occurs when two identical screens with different colors are printed one on top of the other.

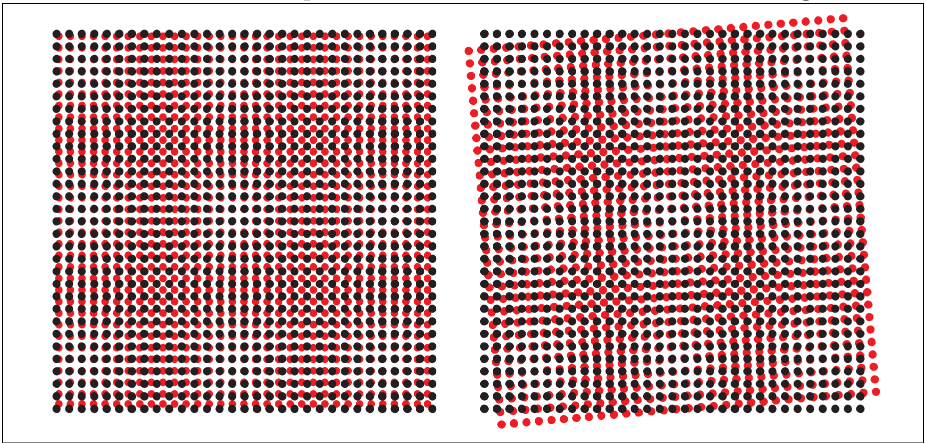
In the printing press, there are always slight fluctuations among the color separations. As a result, the screen dots are printed sometimes on top of each other, sometimes beside each other. The ensuing color impression is very different, depending on whether the process colors appear on top or beside each other. The diagram below illustrates this point.



What are Moirés?

If two screens with slightly different screen frequencies are placed one on top of the other, disturbances occur which can be compared to the interference found when two neigboring radio stations overlap. This overlapping effect of two screens is known as moiré. The same effect also occurs when two screens are rotated slightly in opposite directions. To illustrate this point, the diagram below shows you a moiré resulting from the variation in screen frequency and one where the screens are rotated in opposite directions.

Example of moirés as a result of different screen frequencies (left) and rotation of the screens (right):



Moirés can occur not only in the overprint of screens which do not match but also between fine, even patterns in the original and the screen. For example, they can occur between the stripes of a shirt and the screen. This type of moiré can be avoided by using Diamond Screening which is described later on.

In a similar fashion, moirés can also occur between the original and the scan screen of the scanner. These moirés can be avoided by scanning the original with a higher resolution.

Some Notes on PostScript

PostScript is a page description language which was originally developed for the creation of black-and-white pages, comparable to a special programming language. In the meantime, PostScript has also become standard for high-quality color work.

The exposure of color separations is controlled by means of the following trick.
When color sets are being output, the separations are sent one after the other to the RIP. The RIP, however, does not regard these as separations but rather as a job with four pages. As a result, it cannot allocate any colors directly and, consequently, also cannot allocate the screen angle.

Allocation of Colors to Angles

This problem is solved today by the fact that the applications place a screen instruction before every edited page. In this instruction, the screen angle, screen frequency and screen dot are defined. All known applications which output color have this facility.
However, there are some restrictions concerning the accuracy with which screen frequency and screen angle can be defined, and dot shapes often cannot be defined at all.
I.S. screening compensates for these weaknesses by offering the user a selection of screen systems and screen dots via the NT or Mac Utility or via OPC. Despite this, a minimum amount of support is still required from the application to allocate the correct angle to a

page (separation).
The application must at least allow integral angle values to be defined for each separation.
The user then only needs to enter angles of 15°, 75°, 0°, and 45° for the colors C, M, Y, K. The Delta RIP then maps these to the most suited angles of the screen systems.

Sometimes, it is advisable to change the allocation of colors to angles (refer to *Switching Angles* on page 8–3). For details, please refer to the user documentation of the RIP concerned. An advantage of this procedure is that the user can then allocate the available angles to the separation colors as required.

Screening Methods

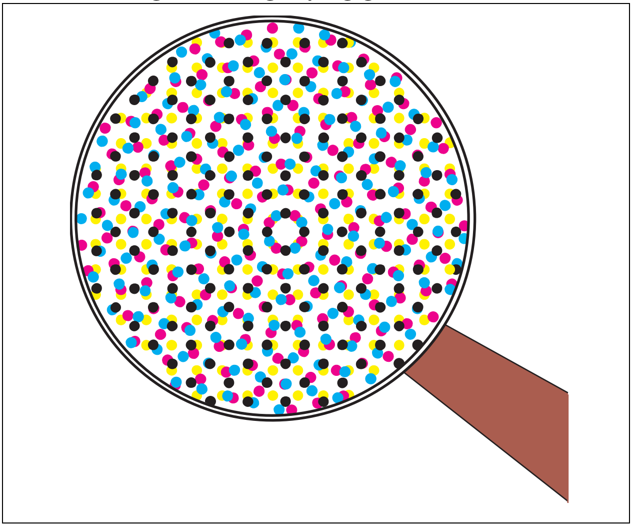
This chapter will skip over older screening methods such as copper engraving or lithography and start from those used with old repro cameras.

For example, a precise, rotatable glass plate where a screen was engraved was placed in front of the repro film to be exposed.
When the color separations were exposed, the image and the screen were overprinted on the film so that a screened image was the result.
Of course, the various color filters for the different color separations were still required.
Experience soon showed that the screens of the separation colors cyan (C), magenta (M), yellow (Y) and black (K= key) had to be positioned at screen angles 15°, 75°, 0° and 45°.
Conventional screening was produced in this way.

Conventional Screens

Conventional screens can also be created by placing contact screens in front of the film instead of a glass plate. In the overprint, these screens produce the offset rosette which is well known to repro persons (refer to diagram below).

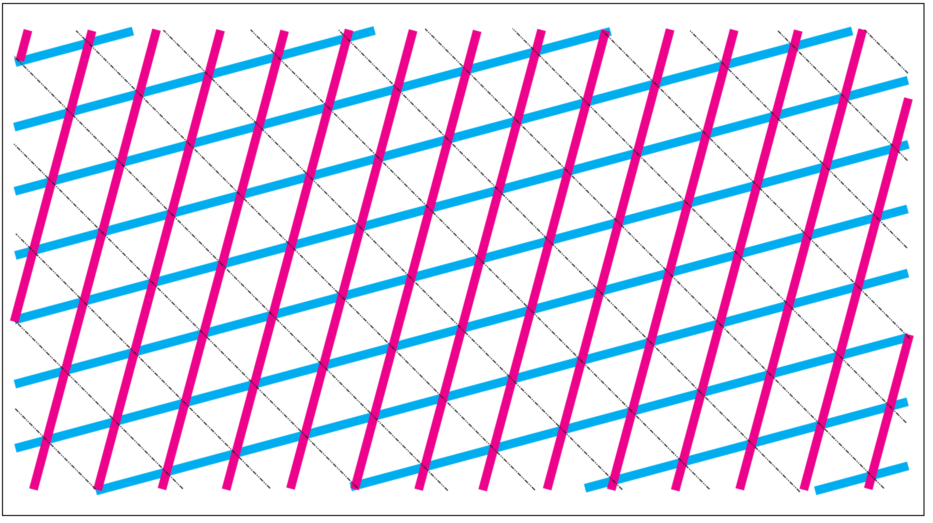
This is what a conventional screen looks like when viewed through the magnifying glass:



Colors C, M and K which provide more detail are spaced at an angle of 30°. The non-defining color Y must be positioned inbetween, spaced at an angle of 15°.
Due to the small distance between yellow and the adjacent colors, a slight yellow moiré may occur in the overprint with conventional screen systems, especially in smooth grayish-green hues.
This moiré is all the more noticeable if color separation films are placed one on top of the other.

These conventional screens, however, require that the screen angles and screen frequencies are very accurate. This is necessary because color separations at an angle of 15° and 75° form a moiré at 45° with exactly the same screen pattern (equilateral triangles). Normally, this cannot be seen since the space is very small.

Cyan and magenta form a moiré at 45° (broken line). A line screen was chosen to illustrate this:



This screen overlaps with the black separation at 45°. If there are only minor deviations in the angle and screen frequency, a monotonous moiré or color shifts occur in many hues. This should not be dismissed too easily as not only quality inspectors with a trained eye (for example, in advertising agencies) see this and will quote really low prices.

Accuracy

If you wish to keep the smudge effects described so far to an acceptable level (1/4 of the screen pattern) on an A2-sized signature with a 60 screen, the tolerance for errors in the angle is 0.003° and 0.00005 for a relative deviation in the screen frequency.
This accuracy is not always possible in the printing press. Despite this, it is best to be as accurate as possible when generating the screen to avoid a series of unintended errors from occuring.
The tolerances specified in the relevant DIN regulations are indeed broad as they were based on the facilities of the time and not on the requirements.

Offset Rosettes

Conventional screens form a fine structure, the offset rosette, as can be seen on page 5–4. The screen dots are arranged around a white space. In the electronic generation of screens, this shape, the clear centered rosette, appears automatically.

No manufacturer knows of another way the rosettes are or were generated. In shadows, this shape has slight advantages over the so-called dot centered rosette where a screen dot is in the center of the circle.

Rational Screens

Rational screens were created at a time when computers and memory were still very expensive. Rational screens attempt to reproduce conventional screens as accurately as possible or, if this is not possible, by means of a trick.

Let us first look briefly at some of the terms used here.

In mathematics, the term “rational numbers” is used. These are numbers which can be presented as fractions of integers.
For example: 1/3; 41/153 or ¼ =0.25.

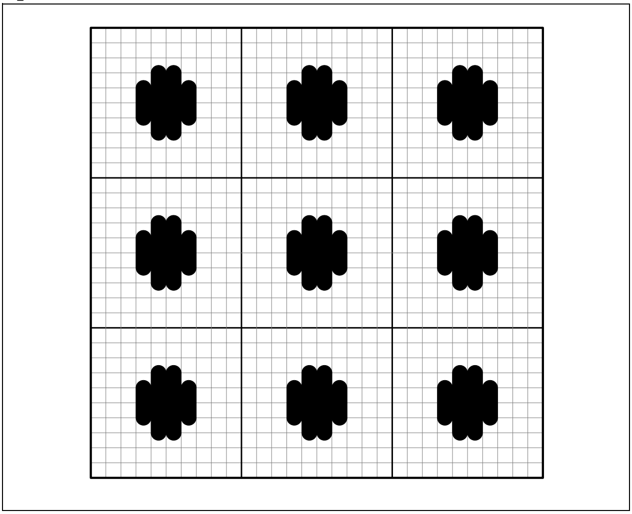
The opposite of this is irrational numbers. They cannot be presented as fractions of integers.

For example: $\sqrt{2} = 1.414213562373...$

or
$\tan(15°) = 0.2679491924311...$

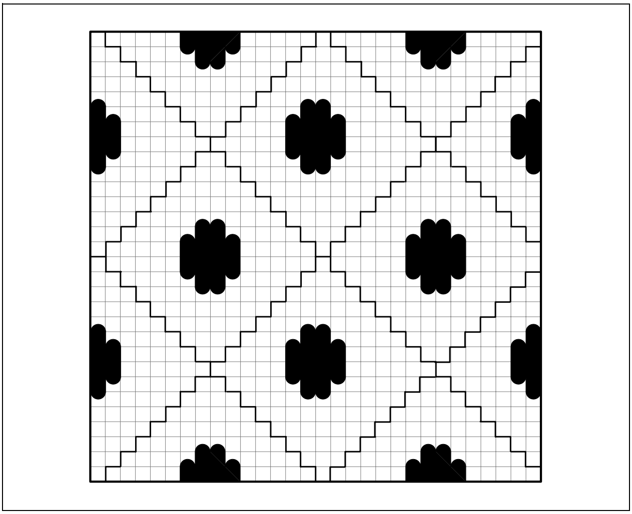
Rational screens are created into the dot matrix of the imagesetter. The angles created in this way have a rational tangent. This is where the name of the screen comes from. How to create angles such as 15° or 75° “exactly” is described in the section *I.S. Screening* on page 5–16.

"Screen dots 0°": Dots at angle of 0° can easily be created and a large area is screened by simply lining them up in a row:



An RT screen system will be used to describe the rational screens in more detail.
The angles of 0° and 45° can be created into the dot matrix of the imagesetter simply as shown in the respective diagrams ("screen dots 0°" and "screen dots 45°").
A large area is screened by simply lining up the screen dots in a row. The screen frequencies are chosen so that the size of three dots with an angle of 0° is the same as two diagonals of the dots at an angle of 45°.

"Screen dots 45°": Dots at an angle of 45° can be easily created and a large area is screened by simply lining up such screen tiles:



The angle of 15° is replaced here by an angle with a rational tangent: tan(18.43494882292...°) = 1/3.
The screen dots can now be arranged so that a screen dot continues on crosswise after three dots in one direction.
In this way, "tiles" made of 3 x 3 screen dots are formed which can be assembled without any break in between.
The 4th screen angle with -18.43494882292...° is created in the same way.

Diagram of a screen tile for an angle of 18.4°. The pattern is repeated every three screen dots in both directions.

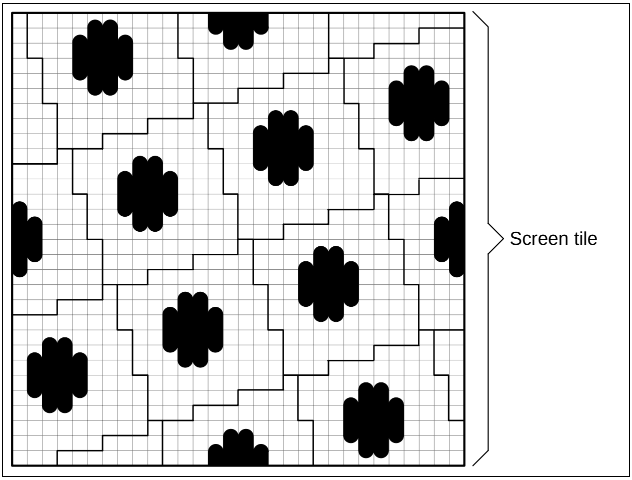
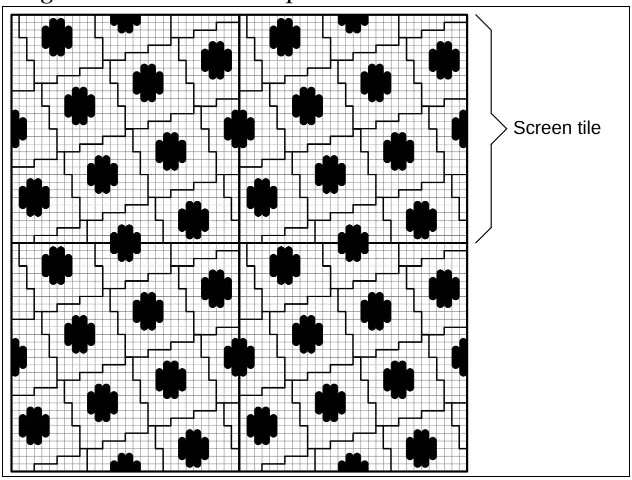


Diagram of a screen composed of screen tiles:



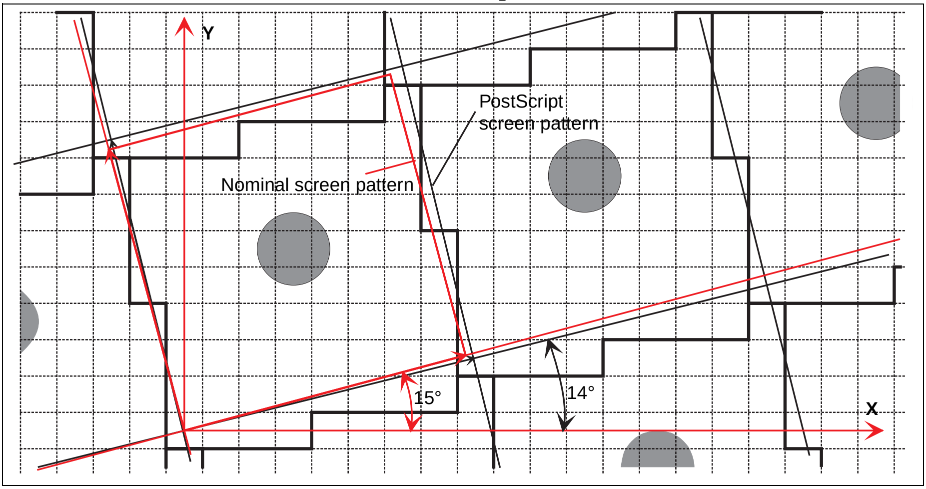
Looking at the diagrams, you notice that not only the individual separations can be composed of screen tiles but also all four separations together can be made from one tile which is 3 x 3 screen dots (0°) large.
This has one great advantage in the overprint: any moirés in the overprint can have a maximum pattern of three screen dots. This pattern is so small that the moirés are rarely disturbing.

On the one hand, this is a very rough match of the conventional screens, but on the other a clever screen system with very good overprint properties.

Standard PostScript Screening

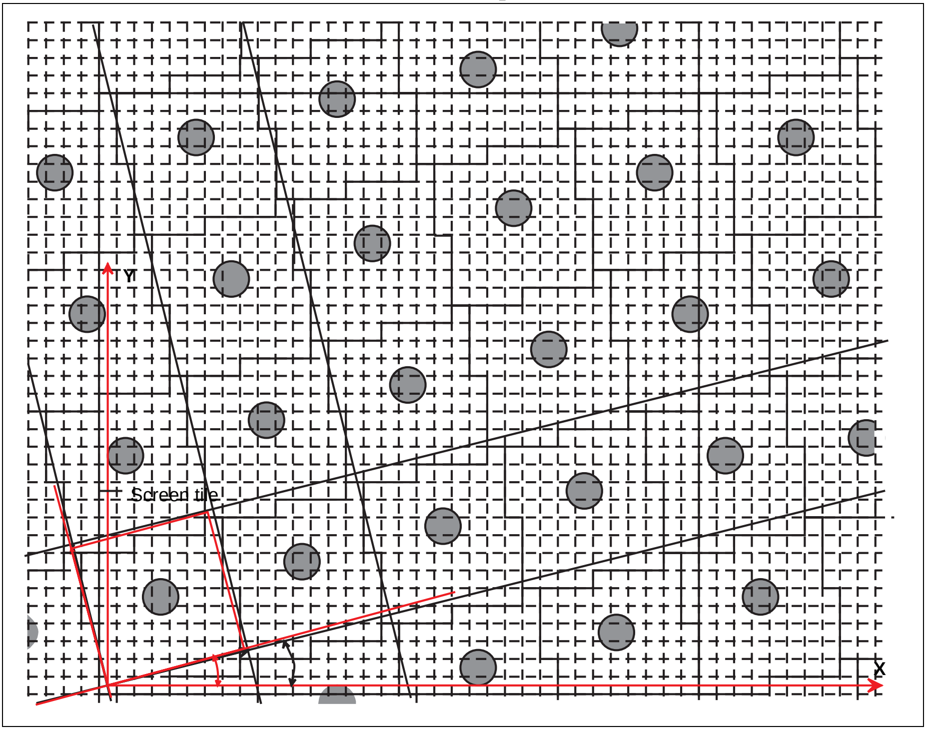
PostScript screening is the simplest method of generating rational screens. The screen dots must be created into the dot matrix of the imagesetter.
A square is placed around a rotated screen dot. The next possible angle is used where the coordinates of the screen dot pass through whole recorder pixels. A large tile is made of the individual screen patterns. The screen can be created by placing the pattern continuously one after the other. In our example, the tile is made of 4 x 4 screen patterns.

Standard PostScript screen:



Not many screen angles and screen frequencies are possible with this single cell approximation. Even if the deviation in this example is only 1°, it is sufficient to create visible moirés in the overprint. Combinations with usable overprint properties are seldom produced.

Standard PostScript screen tile:



The user should be aware that, if standard PostScript screening is used, there are restrictions with regard to the screen frequencies and angles which can be used and, consequently, with regard to quality.

HQS Screening

In HQS screening, a screen cell is made up of many screen dots to reproduce the angles better.
The coordinates of the screen dots only have to pass through a full recorder pixel after several screen dots. This type of cell screening makes it possible to reproduce the angles and screen frequencies relatively well. In this process, the cells or screen tiles can be very large. Since these tiles contain redundant information, the memory required in the computer can be reduced considerably by means of a trick.

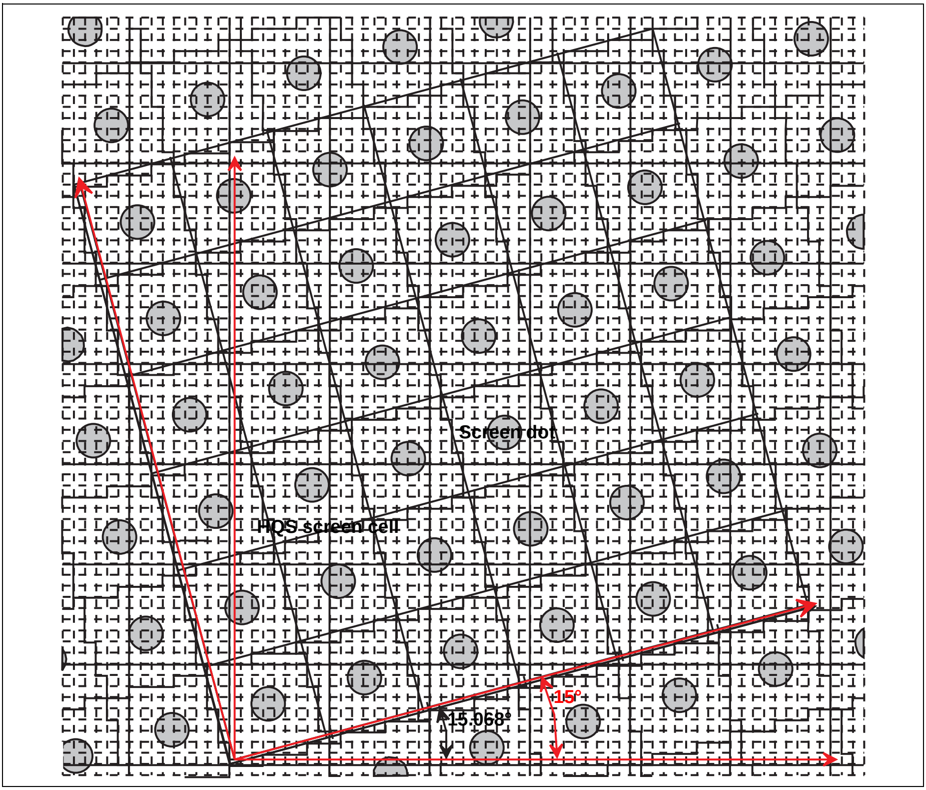
A screen can be composed of noticeably smaller rectangular "screen bricks" which cannot abut each other as is the case with square screen tiles but are staggered similarly to bricks.

A computer program was developed with which combinations of screen angles and screen frequencies could be determined without any moiré being produced in the overprint.

HQS screening and the RT screening described beforehand use screen tiles made of several screen dots. It is an enhancement of the PostScript screening described earlier.

HQS screening emerged as the best method during a Seybold quality test. In other words, it is better than anything other companies can offer. During an internal test, HQS screening was beaten by I.S. screening which will be described in the next section. HQS screening clearly proved to be the second-best procedure.

HQS large cell: The screen pattern which is to be achieved (red arrows) and the screen cell actually generated (black arrows) match each other well.

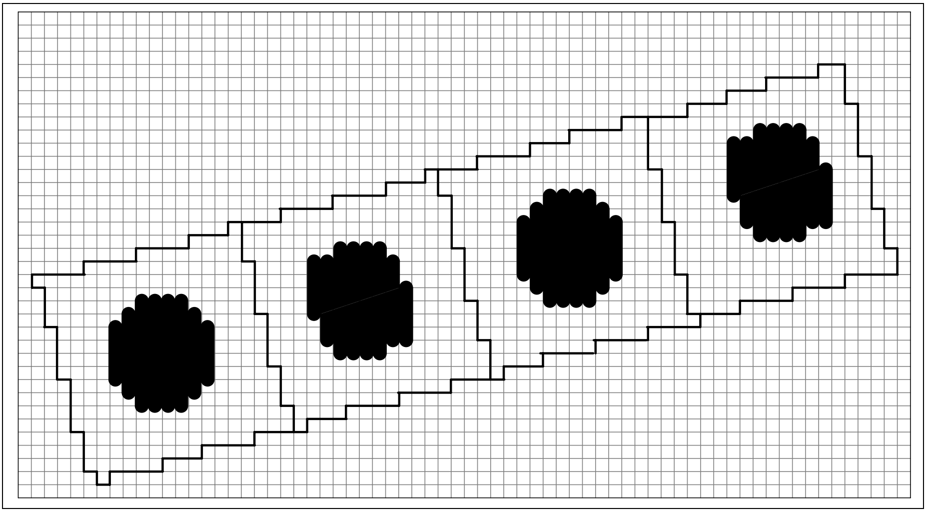


The rational screening methods discussed so far and how they are used as well by other companies are always linked to the dot matrix set in an imagesetter. Only certain combinations of screen angles and frequencies can be created with them and, consequently, there are also restrictions in quality.

I.S. Screening

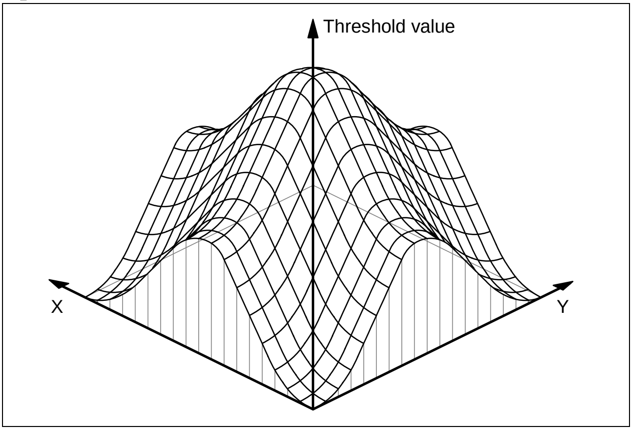
High-end technology from the repro world became accessible to PostScript with the introduction of I.S. screening. Screen angles and screen frequencies can be created with absolute precision using this method.

Creating an angle of 15° just with 3 steps ahead and one to the side is not so simple as is the case with rational screens. The sequences involved in creating the screen dots are irregular and do not repeat themselves.



A dot matrix and not a screen tile forms the starting point for creating the screens. This matrix consists of 128 x 128 elements at present and the dot shape is filed as 12-bit gray values there.

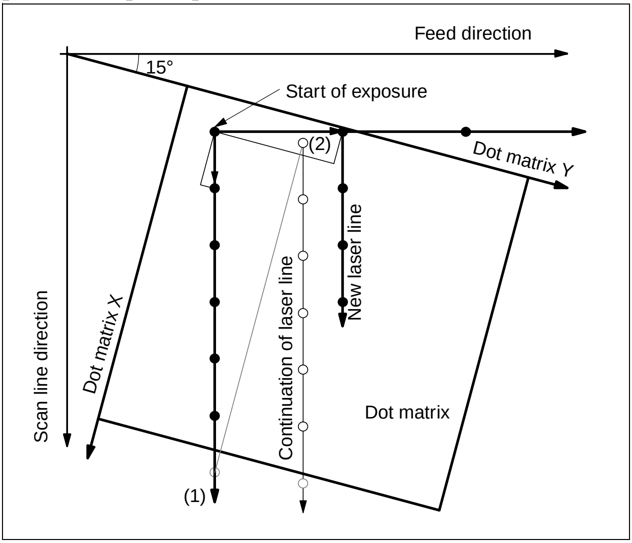
Diagram of a dot matrix: In a matrix where the edge is 128 elements long in X or Y direction, gray values are saved which are shaped something like this if a rounded square dot is used:



The various screen angles are created by converting the coordinates from the coordinates system of the recorder to the coordinates system of the dot matrix which is mainly rotated.

Technically, this transformation is performed in a screen computer which calculates the coordinates in the dot matrix on-the-fly.
The computer proceeds as follows:
With one dot defined as the starting point, the address increments in X and Y direction are added up very accurately. In this way, the comparison coordinates are calculated to the dot matrix. The gray value saved here is compared with the density found in the image and, depending on the result of this comparison, the recorder pixel is reproduced. The area reproduced corresponds to the horizontal cutting plane through the dot matrix.

Transformation of the coordinates in the screen computer. The principle is described below:



If the limits of the screen cell are reached during calculation, the exceeding bit is simply cut off and new comparison coordinates are automatically created. The computer continues on from here.
At the end of the line, the starting point of the new line is determined by adding the address steps to the starting point of the previous line.

The screen computer does not address every element of the dot matrix during a run.
Different elements are used in every run for the angle of 15° shown in the example. For angles such as 0° and 45°, it is possible that the same elements are always addressed. This will be described in more detail on the pages which follow.

With I.S. screening, the screen pattern can be accurate to ± 0.000 000 015 and the maximum angle error can be accurate to ± 0.000 001 2 degrees.
In concrete terms: The first systematic deviation from

the nominal position by just one recorder pixel will only occur on films which are larger than 80 m x 80 m, in other words, something which would not be on any film format.

Accuracy in rational screening methods varies. Inaccuracies amount to some screen dots in every normal imagesetter format.

A further improvement in quality can be achieved with this technology without involving much more work for the customer. The number of imagesetter pixels is doubled in fast scan direction. In this way, the reproduction of the dot shape is not only better but also the number of pixels per screen dot is increased and, consequently, also the number of density levels which can be displayed.

Diagram of a screen dot with symmetric resolution in fast scan direction (direction of rotation of laser mirror or drum) and scan direction (feed direction). Size: 16x16 pixels :

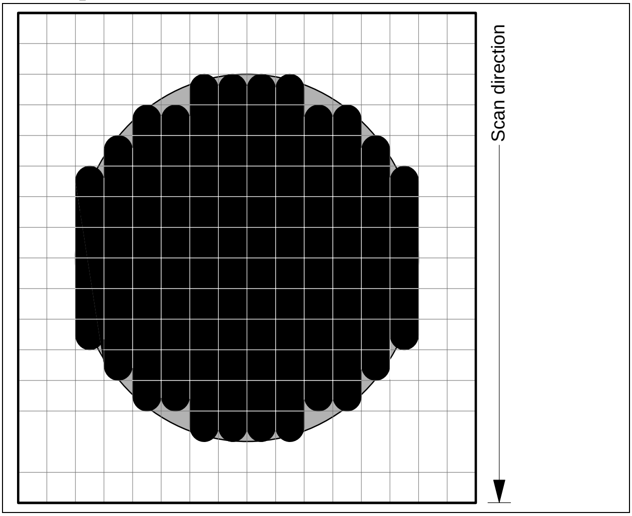
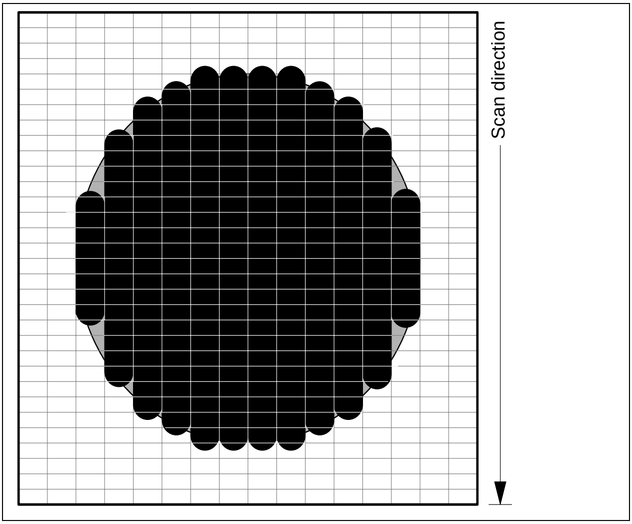


Diagram of a screen dot with double the resolution in fast scan direction (direction of rotation of laser mirror or drum) compared to slow scan direction (feed direction). The reproduction of the dot shape is considerably better. Size: 16x32 pixels:



It is not hard to see that it is advantageous to have many recorder pixels per screen dot.

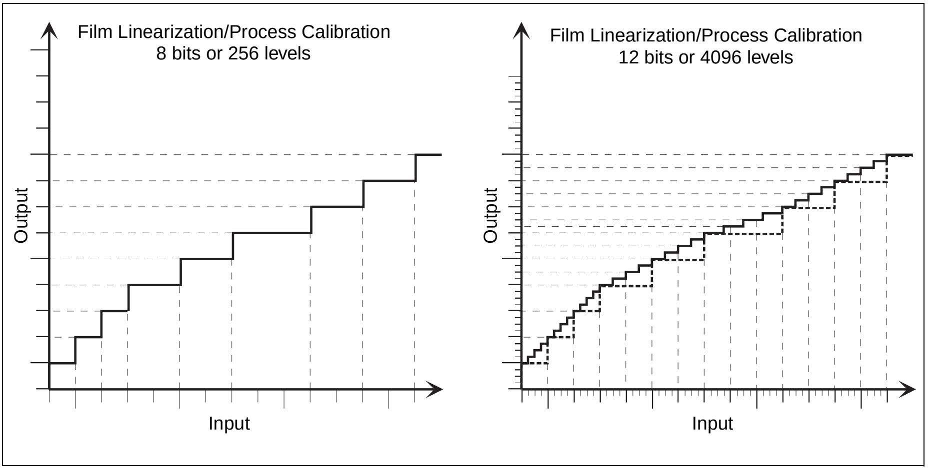
An example of this:
If a 120 screen (300 dpi) is exposed with a recorder resolution of 1000 l/cm (2540 (lpi), a screen dot made of 8 laser lines is created. Only 8 x 8 = 64 different density levels can be displayed using such a screen dot. That is by no means enough. Even if the imagesetter pixels are doubled in fast scan direction, 128 density levels are not enough to show a gray scale smoothly with an ink coverage going from 0% to 100% . Breaks are very noticeable, in particular in the dark end of the scale.

Because the human eye is well able to distinguish differences in dark colors, approximately 1000 density levels are required to display a vignette smoothly, at any rate if it is made up of even areas. This subject will be discussed in more detail in Chapter 8, *Tips and Tricks*.

A special multi-dot technology is used in addition in Delta Technology for I.S. screening to obtain such a great number of density levels. With this technology, screen dots which lie very close together vary slightly but in a way that this is not perceived by the eye. As a result, more than 1000 density levels are always available.

Not only vignettes but also film linearization and calibration of the printing process benefit from this. In the diagrams below, you can see that density levels are lost during a conversion from 8 bits to 8 bits. This is something you do not want at all.

Calibration with 8 bit and 12 bit resolution:



If mapping in process calibration is from 8 bits to 8 bits, not all input levels can be mapped to an output level. As a result, levels are lost and breaks occur in vignettes (refer to *Vignettes* on page 8–5). If mapping in process calibration is from 8 bits to 12 bits, for every input level there is an output level which can be distinguished when reproduced due, among other things, to the greater resolution in the 12-bit dot matrix. Normally, no levels are lost during a conversion from 8 to 12 bits.

Soft I.S.

It is very difficult to implement I.S. screening just described with sufficient speed in software. The Soft I.S. method combines the easy implementation of HQS screening with not quite the entire precision of I.S. screening. Soft. I.S. uses the screen bricks of HQS screening and adds corrections at certain, precalculated positions which compensate for the angle and frequency errors of HQS screening. We will not go into the algorithms used in this method.

This concludes our excursion into widely used screening methods. This also rounds off the chapters which deal with the basics of screening. In the remaining chapters, you will find some examples of screen dot shapes, screen systems as well as typical cases of their application. The printed examples can be folded out to make a direct comparison easier.

Screen Dot Shapes

There are different screen dot shapes for various kinds of purposes and their use will now be described briefly.

All screen dots are optimized with a program which uses methods of artificial intelligence and fuzzy logic. You could say that screen dots are created on the basis of design rules. This means that top quality is always produced.

Your attention is now drawn to some aspects concerning the structure of screen dots:

- Screen dots should be created with a short fringe line and consequently be as compact as possible. This is to restrict effects such as overexposure during platemaking and dot gain in printing from occuring. A study made by FOGRA (FOGRA research report no. 1.206 (available in German only): Jürgen Mandt, Übertragungseigenschaften elektronisch erzeugter Rasterpunkte für den Offsetdruck) has shown that it is also better to generate the dots as sharply as possible as it is then easier to reproduce them and process them further.
- While it is still possible to etch unsharp dots on the film and correct them in this way, nowadays corrections are made in the image editing system and not on the film. This is something which can be done when working with recorders with inferior laser optical systems.

Defaults for Screen Dots

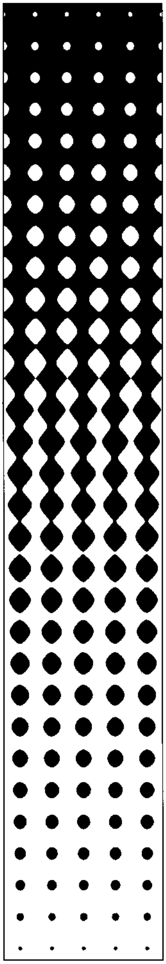
For PostScript screens, the dot selected is only used as a default and can be changed by the application.

For all other screen systems (RT, I.S.), the dot set (Heidelberg screen dot shapes) is fixed and cannot be changed by the application.

These dots offer the best solution with regard to speed as well.

Of course, different dot shapes can also be defined for HQS screening. Here, too, the same aspects as in I.S. screening apply when selecting them. For that reason, they are not described separately.

Elliptical Dot



Dot:	Elliptical
Screen frequency:	2l/cm coarse screen

The Elliptical dot shape is the screen dot recommended for offset printing.

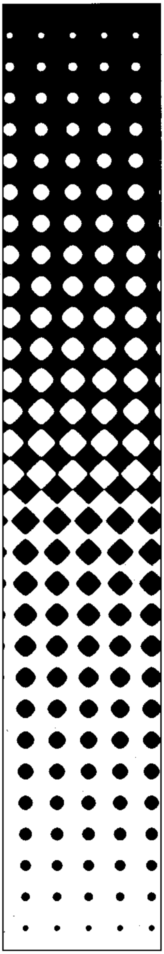
This dot starts off as an almost round dot in the highlight area and becomes increasingly elliptical. When the dots first join at 44%, they become somewhat rhombic. After the second time they join at 61%, rhombic shapes are first created, then they become elliptical and in the shadows, round holes appear.

In offset printing, there is a density jump where the dots touch each other which in the case of an elliptical dot is divided up into two sections. This reduces the effect and makes it easier to control by means of gradation curves.

This is the ideal dot shape for offset printing.

This dot shape is also recommended for screen printing, letterpress printing and O/G conversion.

Round-Square Dot



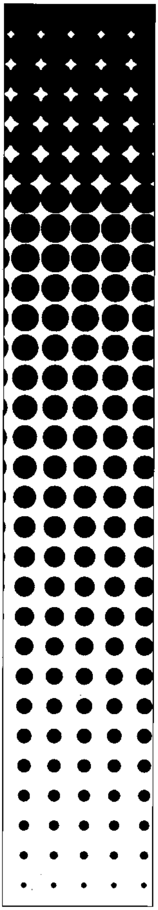
Dot:	Round-Square
Screen frequency:	21/cm coarse screen

The Round-Square dot shape is the classic dot shape for offset printing which stems from the glass engraving screen mentioned at the beginning of this book. In PostScript, this dot shape is also known as a euclidian dot. This dot starts off as an almost round dot in the highlight area, becomes increasingly square in the mid-tone. Round holes appear in the shadows. The dots join together at 50% and are slightly staggered to smoothen the density jump. This also makes it easier to control by means of gradation curves.

This dot shape is used frequently for motifs as in this example where the density jump resulting from printing is used to increase the contrast in midtone. However, it makes better sense to set the contrast by changing the gradation curve in the image editing system and then to use the elliptical dot for exposure.

To a certain extent, this dot is still also used in traditional printing houses where a change in production methods (changing the process calibration, quality control, etc.) would involve too many complicated steps. A switchover is not absolutely necessary since smooth vignettes can also be produced with this dot shape.

Round Dot

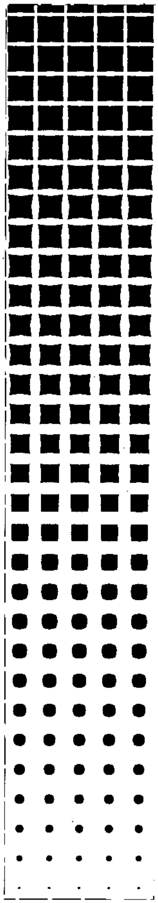


Dot:	Round
Screen frequency:	21/cm coarse screen

The Round dot shape was developed for flexographic printing. With this completely round dot, the dots join at 78%. After this, the holes first appear pincushion-shaped, becoming round in the shadows.

In flexographic printing, a letterpress printing method with elastic print formes, the screen dots are squashed and, as a result, there is considerably more dot gain here than in offset printing. With this dot shape, the dots join together at a point where the screen dots are already smudged. A density jump which normally occurs is avoided as a result of this late dot joint.

Flexographic printing is mainly used in the packaging industry (plastic carrier bags, etc.).



Pincushion-shaped Gravure Dot

Dot:	Pincushion_1
Screen frequency:	2l/cm coarse screen

This dot shape was developed as an option for the photogravure process. In Europe today, gravure forms are almost exclusively engraved with the Hell Gravure Systems HelioKlischographs. In South-East Asia and Latin America, photogravure is still widespread. This process is used almost without exception for the packaging industry.

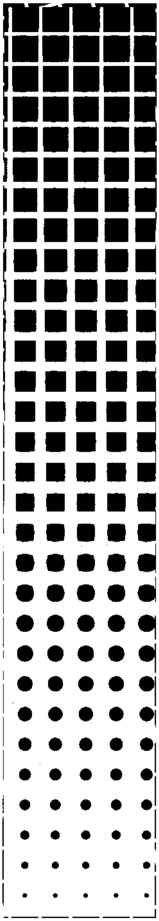
This dot shape can only be used with special gravure screen systems. These systems are similar to the usual screen systems with only the screen frequency limited in its upper values since there is no sense in creating a pincushion-shaped gravure dot with an insufficient number of laser lines.

The Square dot starts off as a small, almost round dot in the highlight area, then becomes square in the midtone and finally pincushion-shaped.

The pincushion_1 shape was selected to balance out underetching effects. These effects are described later on (refer to *Brief Excursion into the Photogravure Process* on page 6–15).

With this dot shape option, a gravure tool is available by means of which you can restrict the maximum ink coverage to between 51% and 79% or the ratio of gutter to cell to between 1:2.5 and 1:8. This setting is necessary since these values differ from printers to printers. With this tool, four dots each with a different ratio for gutter to cell can be set by default. More details about this can be found in the Help function of the tools.

Classic Gravure Dot



Dot:	Square_1
Screen frequency:	2l/cm coarse screen

This dot shape was developed as an option for the photogravure process. It can also be found in the more recent versions of the Delta software. In Europe today, gravure forms are almost exclusively engraved with the Hell Gravure Systems HelioKlischographs. In South-East Asia and Latin America, photogravure is still widespread. This process is used almost without exception for the packaging industry.

This dot shape can only be used with special gravure screen systems. These systems are similar to the usual screen systems with only the screen frequency limited in its upper values since there is no sense in creating a pincushion-shaped gravure dot with an insufficient number of laser lines.

The Square_1 dot starts off as a small, almost round dot in the highlight area, then becomes square in the mid-tone and remains square right into the shadows.

This classic gravure dot proved to be necessary as a changeover of a running production line from the square gravure dot to the pincushion dot involved too many complicated steps for some printers.

With this dot shape option, a gravure tool is available by means of which you can restrict the maximum ink coverage to between 51% and 79% or the ratio of gutter to cell to between 1:2.5 and 1:8. This setting is necessary since these values differ from printers to printers. With this tool, four dots each with a different ratio for gutter to cell can be set by default. More details about this can be found in the Help function of the tools.

Brief Excursion into the Photogravure Process

To understand the underetching effects properly, a brief digression into the theory of photogravure is necessary. In gravure printing, the lower-lying parts of the print form are those which print. Fluid ink is filled into the hollow cells of the printing cylinder. A blade wipes off any color from the surface so that ink is only in the cells. The paper to be printed absorbs the ink from the cells as it is passes between the printing cylinder and the pressure cylinder. There should be an even and stable gutter between the cells in order for the blade to be applied.

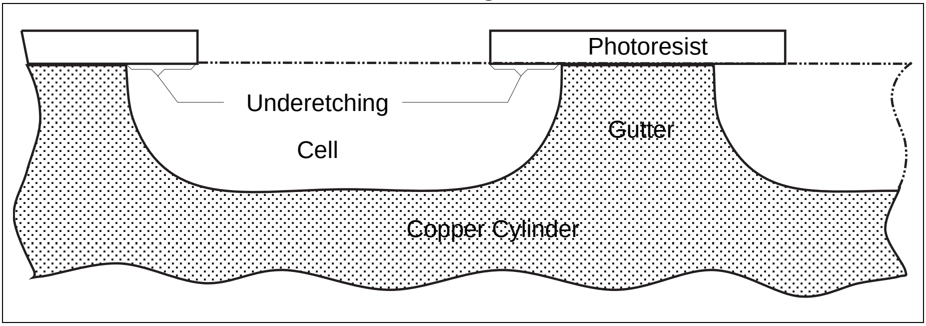
The cells required are created as follows:

Photoresist is applied to the printing cylinder which has a copper surface around 0.3 mm thick. This layer is exposed by a screen film with its dot shape. The exposed parts are hardened and the unexposed areas are washed away. The print form prepared in this way is then etched in a ferric chloride solution. Finally, the cylinder is hard-chrome plated to withstand long periods in the printing press.

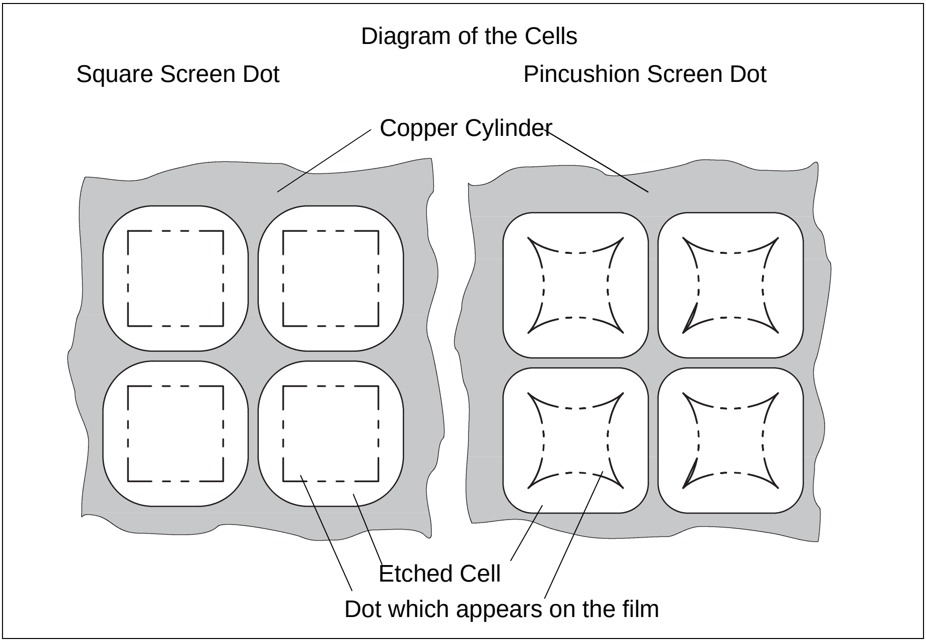
During this process, not only is material removed from under the washed away parts but also from under the gutters. This undercutting is stronger in the center of the gutters than at the sides. Without the pincushion shape which balances out these undercutting effects, the cells would be rounder and not be able to hold as much ink.

The underetching effects can be seen in the diagram which follows where a cross-section of an etched gravure cell is shown.

Cross-section of gravure cell:



Seen from above, the size of the cells appear larger since the cells of the pincushion-shaped screen dot cover a larger area and still have a stable wall. This is what the cells look like:



Screen Systems

In color reproduction, it is not a matter of just supplying four black-and-white films for the four color separations but of obtaining optimal overprint properties of the repros. Screen systems are used to achieve this. A screen system always has four screen angles. The respective screen frequencies can be different. However, they are selected so that moiré in the overprint is kept to a minimum. For that reason, not just any screen frequency may be used in the overprint. Screen systems mainly have several dot shapes with which they work optimally.

We warmly recommend that you use one of the RT or I.S. systems, Megadot or Diamond Screening for your color work.

All the screen systems work as PostScript filter programs. If you select one of the screen systems, only those angles shown in the user interface can be used for exposure. All default angles from an application are only used to select the nearest angle from the activated system.

Various screen frequencies are available within each screen system. The value displayed must be regarded as a nominal value, in other words, not all angles are exposed using exactly this screen frequency. The nominal value mainly refers to 0° or 45°. With reference to the nominal values, the ratio of relevant screen frequencies to different angles remains constant. This means that the properties of the overprint do not depend on the screen frequency but only on the screen system. In most screen systems which are not based on I.S. screening, the properties of the overprint depend on the screen frequency selected. This also applies to the screen filters of HQS screening.

In the meantime, screen filters similar to those in the I.S. screen systems are also available for HQS screening. The criteria for selecting the screen systems is similar.

Defaults for Screen Frequencies

The screen frequency should be based on the sensitivity of the human eye in discerning objects. In a 60 screen, the individual screen dots can just about be distinguished. Above this level, they are no longer visible. A reproduction with 60 l/cm (150 lpi) is sufficient for monochrome imaging.

Conventional screens form a large rosette in the overprint. How visible the rosette is depends on the hue. FOGRA studies have shown that a visible rosette can be judged as if it were visible in a screen which is coarser by a factor of 1.5. This means that a rosette is indeed still visible with an 80 screen. An 80 screen at least should be used for high-quality art printing.

Printing aspects are often more important when it comes to selecting the screen frequency. The smallest printable dot or the smallest printable gap is decisive here. Because the human eye can easily discern objects in dark hues, it is necessary to print gaps as small as possible. In the table below, the maximum ink coverage which can be printed just short of 100% ink coverage is listed.

Smallest printable dot and max. ink coverage

Screen Frequency		Diam.	Max.	Diam.	Max.	Diam.	Max.
l/cm	lpi	µ	%	µ	%	µ	%
40	100	10	99.8	15	99.7	20	99.5
60	150	10	99.7	15	99.4	20	98.9
80	200	10	99.5	15	98.8	20	97.9
120	300	10	98.8	15	97.5	20	95.5
240	600	10	95.4	15	89.8	20	81.9

Because the human eye can easily discern objects in dark hues, losses of even 1.0% affect shadow definition. Which dot size can still be printed depends on many factors, in particular on the paper used. A size of 7.5µ can just about be copied but no longer printed. Relatively large screens are normally printed because they are easier to work with. Our experience with Diamond Screening has shown that dots with a diameter of 20µ are still stable when printed. This becomes difficult with smaller dots.

In newspaper printing, a 34 or 40 screen has become customary. In Europe, magazines and catalogs are generally printed in a 60 screen, with an increasing tendency towards a 70 screen as is already standard in South-East Asia. An 80 screen is recommended for art printing on coated paper.

When a screen system is selected in I.S. screening, a screen frequency must always be defined. This value is used as the default if the application does not provide one itself. For that reason, it is not absolutely necessary for the user to define a value in the application. If the user does define a value, the same value must be used for all the angles.

Before the screen frequency is selected, the user should know what values are available at the RIP to avoid unexpected results. Each screen system only has a certain number of screen frequencies. The value defined by the application is only used to select the nearest value in the system. This applies as long as the screen frequency is not set as “fixed”. If this is the case, the default from the application is ignored.

Screen System Extensions

Extensions have been developed for most screen systems. They make extremely fine screen frequencies possible: up to 240 l/cm (600 lpi) for recorder resolutions of 2000 l/cm (5080 dpi). With these screen frequencies, screen dots are generated with only 8 or 10 laser lines per screen dot. Naturally, it is difficult to create screen dots with so few laser lines. For that reason, they have been optimized very carefully. The multidot technology mentioned earlier is, of course, used here.

With the extensions, art printing can be reproduced in absolutely top quality. Great care is required in platemaking and in printing, preferrably dry offset, with extremely fine screens. With screen frequencies above 120 l/cm, the naked eye can no longer perceive differences in the smoothness of the printout or in the wealth of details. Consequently, it makes sense to use such high screen frequencies in special cases only.

The extensions are at the same time a tool with which productivity can be increased. For example, the standard screen frequency of 60 l/cm (150 lpi) can be exposed with a recorder resolution of 500 l/cm (1270 dpi) instead of the usual 1000 l/cm. You should make use of the greater speed and its advantages.

The screen quality of the extensions is excellent. Due to the top quality possible in Delta Technology with I.S. screening, the attention of customers who have a particularly critical and trained eye is drawn in the user documentation to the fact that the usual high quality cannot be guaranteed for all cases.

What screen systems are available?

I. S. Screens

I.S. screen systems are conventional screen systems where the angles are spaced at 60° between the colors which provide more detail (cyan, magenta and black). This large spacing results in better properties in the overprint, especially in the standard elliptical dot.

The I.S. screen systems do not provide approximations but the exact conventional screens with the highest quality. No other screen system can achieve this.

Spot Colors

Screen systems IS Classic, IS Y60° and IS Y30° can be combined for spot colors which are to be printed not only as a solid tint. These systems are described in the next section of this chapter. To avoid moiré in the overprint, you should remember that screen angles 60° and 30° are only spaced 15° away from the adjacent angles and, consequently, you should allocate the colors accordingly. In other words, there should be a slight contrast to the adjacent colors or the spot colors should be non-defining like yellow.

Fine black of the RT Y45° K fine screen system is also very suitable for a spot color with these systems and can be used without any restrictions. Another way is to position a spot color at the angle of a color which has the least opaqueness.

Screen angles 60° and 30° of the IS Y60° and IS Y30° systems can be combined with the Megadot screen which is described at a later point.

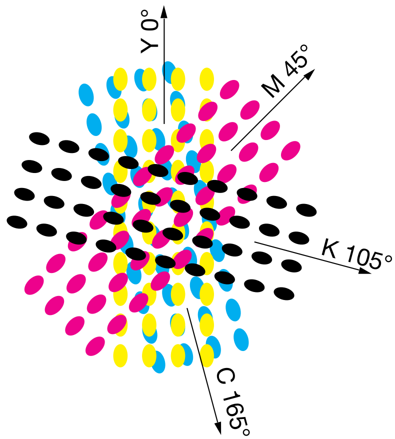
The neatest solution is the use of Diamond Screening. Here, the different dot gain in printing must be taken into account (process calibration).

IS Classic

The IS Classic screen system is the classic, conventional offset screen system.

The position of the angles in this system can be seen in the diagram below. The same angle allocation applies to all other screen systems.

Angle allocation in the IS Classic screen system:



C = Cyan, M = Magenta, Y = Yellow, K = Key

As can be seen in the table of relative screen frequencies below, yellow at 0° is somewhat finer than the other screens. This reduces yellow moiré which is possible with conventional screens. Refer to conventional screens (page 5–4).

Color	Screen Angle	Relative Screen Frequency
C	165.0°	0.943
M	45.0°	0.943
Y	0.0°	1.000
K	105.0°	0.943

IS Y60°

The IS Y60° screen system is a conventional screen system where yellow is positioned at 60°. All colors in this system have exactly the same screen frequency.

This screen system is better suited for flexographic and screen printing than the IS Classic screen system. Since this screen system does not have a 0° angle, moirés between the screen and the screen grid or screen drum which colors the flexographic form are kept to a minimum.

Some customers use this screen system because they believe there are advantages in printing through not using the 0° angle, for example, no dot slur or dot doubling. Avoiding the 0° angle for yellow does not play a role in whether a screen is visible or not since yellow is non-defining anyway.

The allocation of colors to the screen angles and the relative screen frequencies can be seen in the table below:

Color	Screen Angle	Relative Screen Frequency
C	165.0°	0.943
M	105.0°	0.943
Y	60.0°	0.943
K	45.0°	0.943

IS Y30°

The IS Y30° screen system is a conventional screen system where yellow is positioned at 30°. All colors in the system have exactly the same screen frequency. It corresponds to the IS Y60° screen system, but for negative processing.

This screen system is better suited for flexographic and screen printing than the IS Classic screen system. Since this screen system does not have a 0° angle, moirés between the screen and the screen grid or screen drum which colors the flexographic form are kept to a minimum.

Some customers use this screen system because they believe there are advantages in printing through not using the 0° angle, for example, no dot slur or dot doubling. Avoiding the 0° angle for yellow does not play a role in whether a screen is visible or not since yellow is non-defining anyway.

The allocation of colors to the screen angles and the relative screen frequencies can be seen in the table below:

Color	Screen Angle	Relative Screen Frequency
C	165.0°	0.943
M	105.0°	0.943
Y	60.0°	0.943
K	45.0°	0.943

IS CMYK+7.5°

The IS CMYK+7.5° screen system is a conventional screen system which is rotated by 7.5°. All colors in this system have exactly the same screen frequency. This system was developed especially for screen and flexographic printing. Rotating the system by 7.5° keeps moirés between the screen and the screen grid or screen drum which colors the flexographic form to a minimum

For this same reason, the system is also very suited for O/G conversion with a HelioKlischograph. The HelioKlischograph can only engrave lines in circumferential direction. Since this screen system does not have 0° or 45° angles, it works very well with the engraving screen of the HelioKlischograph for the descreening of originals. We will not go into further detail about O/G conversion here as this is well known at the gravure printers anyway and nowadays work is mainly directly with computer to cylinder.

This screen system is also very suited for conventional offset printing. It has the best overprint properties of all conventional screen systems.

The allocation of colors to the screen angles and the relative screen frequencies can be seen in the table below:

Color	Screen Angle	Relative Screen Frequency
C	172.5°	1.0
M	52.5°	1.0
Y	7.5°	1.0
K	112.5°	1.0

RT Screens

These screen systems are old ones where all angles have an rational tangent. Of course, all “rational” screen angles can be reproduced exactly with the I.S. screen mechanism. There are often great differences in the relative screen frequencies for the various color separations of these screen systems.

The RT screens were developed for the first scanners/recorders with electronic screening. However, the overprint properties are noticeably better here than in standard PostScript screening which was developed much later (standard PostScript screening was not developed by Heidelberger Druckmaschinen AG).

RT Classic

The features of this system were already described in the chapter *Screening Methods* as an example for rational screens. It is not the well-known offset rosettes which appear in the overprint but rather a weak square structure.

The allocation of colors to the screen angles and the relative screen frequencies can be seen in the table below:

Color	Screen Angle	Relative Screen Frequency
C	161.6°	1.054
M	108.4°	1.054
Y	0.0°	1.0
K	45.0°	0.943

RT Y45° K fine

The RT Y45° K fine rational screen system is a further development of the RT Classic screen system. In this screen system, yellow is positioned at 45° and a fine black with a screen frequency with a factor of 1.4 is used. This gives you a very smooth overprint. Yellow moiré which may be possible in conventional screening cannot occur with this system which is well suited for the reproduction of skin tones.

This screen system is more suited for flexographic and screen printing than the RT Classic system. Since this screen system does not have a 0° angle, moirés between the screen and the screen grid or screen drum which colors the flexographic form are kept to a minimum.

The dot gain in printing for fine black is generally different to the other colors. This should not be forgotten when creating the color data (refer to *Process Calibration* on page 3–9).

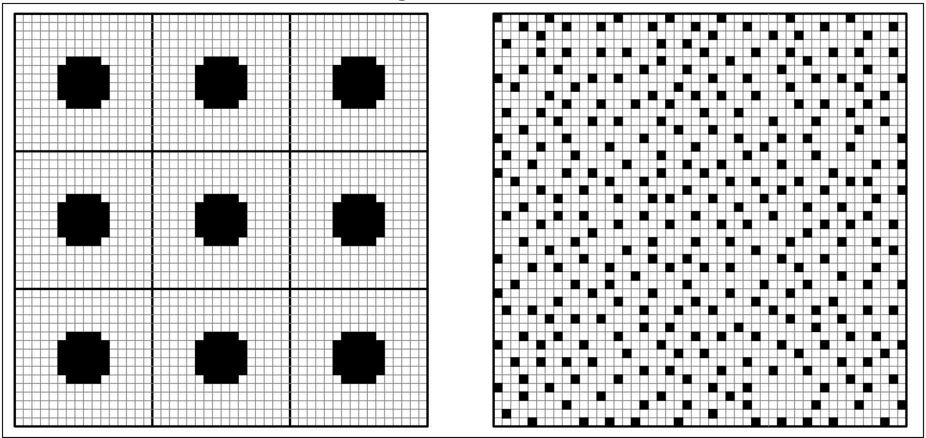
The allocation of colors to the screen angles and the relative screen frequencies can be seen in the table below:

Color	Screen Angle	Relative Screen Frequency
C	161.6°	1.054
M	108.4°	1.054
Y	45.0°	0.943
K	45.0°	1.414

Diamond Screening

Diamond Screening is a frequency-modulated screen. In this screen system, the screen dots do not become larger as density increases but rather the number of exposed dots increases until they touch each other and grow together. The dots appear to be distributed at random here. However, attention is paid that smooth areas are reproduced as smoothly as possible and at the same time repetitions in structures are avoided. If the dots were really distributed at random, the images would appear very unsettled.

Comparison of standard screen dots and Diamond Screening:



With Diamond Screening, it is possible for a print to have an almost photo-like quality. A sharpness in details is achieved which is not possible with any other system. Disturbing offset rosettes do not occur in this system. Your print comes closest to the quality of a color photo.

Comparison with an Image in the IS Classic Screen System

To demonstrate the extremely high level of excellent detail in Diamond Screening, the image opposite was reproduced using both Diamond Screening and the IS Classic screen system with Elliptical dot shape.

Another important advantage of Diamond Screening can also be seen here.
No moirés can occur between the fine structures of the textiles and the screen. Diamond Screening is most suited for use in technically difficult reproductions with many fine details, such as details on loudspeakers, fine textiles or wood grain, satellite pictures, etc.

A note on this subject in passing: Moirés between the original and the scanner screen cannot be eliminated subsequently by any means. The only remedy here is to rescan the original using a finer resolution.

Two dot shapes are supplied with Diamond Screening: Diamond1 and Diamond2. Diamond2 was developed for the DrySetter and is more compact than Diamond1. For this reason, there is less dot gain in platemaking and in printing, making further processing more stable. Dot shape Diamond2 only may be used with the DrySetter. Diamond2 can also be used with other devices.

Effects such as overexposure during platemaking or dot gain in printing are mainly marginal effects as described in Chapter 3, *Practical Aspects of Printing*. The fringe line in Diamond Screening which is large in comparison to normal screen dots requires special attention which should be considered for further work.

Extremely hard dot films such as Kodak S2000 are recommended for exposure. The settings at the recorder must be performed with great care. The larger dot gain in printing should be compensated with the process calibration of the Output Manager Utility. As an alternative, corrections can be made to the gradation when scanning. Details about this can be found in the *Diamond Screening - User's Guide* documentation.

During platemaking, a clean environment and a high level of care are important when working with Diamond Screening. Cutting lines cannot be covered up due to the tiny pixels used. Diffusion films must not be used. In particular, poor contact should be avoided. The time required to form the vacuum which keeps the assembly attached to the plate should not be shortened. The vacuum frame should be set that 6μ to 8μ lines can still be copied.

Working with dry offset (Toray plate) is also recommended. In general, the printing conditions should be monitored closely and kept constant. Well-known errors in printing such as dot slur, dot doubling or dot filling-in in the case of high densities should be avoided if at all possible. Register should also be set carefully since minor register errors are first only noticed not as colored lines but through the unsharpness of the reproduction. It would be a pity to impair the excellent reproduction of detail found in Diamond Screening by minor register errors.

Megadot Screen

The Megadot screen which is a new development cannot be compared to the screens described so far. Megadot screens do not create an offset rosette but a remarkably smooth overprint. This superior smoothness is very noticeable in screens which are coarser than the standard 60 screen.

Megadot CM0°

The use of the Megadot screen is recommended whether in color newspaper printing with coarse screens (where the offset rosette is very disturbing) or in high-quality art printing.
In high-quality art printing, an excellent smoothness of the printout is even possible with relatively low screen frequencies, making printing easier.
The fact that there is no offset rosette means a better reproduction of fine details.

Megadot and Diamond Screening:

Comparison with an Image in the IS Classic Screen System

The Megadot screen is mainly a line screen. Such screens have the great advantage that two colors with an angle of 90° can be printed beside each other without resulting in a color shift. With this screen system, cyan and magenta are positioned at 0° and 90°, yellow is at 45° and black is created as a fine screen at 45° as well.

The line screens used almost have the same dot gain in printing as conventional screens. In contrast to Diamond Screening, normal care is required when working with Megadot, the same amount you would take when working with conventional screens, Only the fine screen for black has a larger dot gain as is the case in the RT04 screen system. This should not be forgotten when creating the color data (refer to *Process Calibration* on page 3–9).

In contrast to Diamond Screening, however, moirés between the original and the screen cannot be avoided.

A smoothness in the overprint which was considered impossible can be achieved with the new Megadot screen. At the same time, the high level of detail is improved as offset rosettes no longer exist. Working with this screen system is simple and uncomplicated. It is, in fact, practically the ideal method for offset printing.

Megadot CM45°

Megadot CM45° is a variant of the Megadot CM0° screen just described. It is also essentially a line screen, with the colors which provide more detail (cyan and magenta) positioned at 45° and 135°. Since the human eye perceives horizontal and vertical lines better than slanted ones, the screen cannot be seen as well in the single separation. Yellow is positioned at 0°, and a fine black is used at 45°. The overprint properties are not quite as good as in the Megadot CM0° screen system.

Other Megadot screen systems with set angles are conceivable, for example, for screen printing.

Dot Shapes for Megadot

There are two dot shapes for the Megadot screen: the Megadot and the Megadot Flexo.

The Megadot starts off as a small round dot in the highlight area, then becomes elliptical and continues to become line-shaped. In the shadows, small round holes occur again. This dot shape was developed mainly for offset printing, but is also suitable for other printing processes.

The Megadot Flexo is an inverted Megadot. It starts off as a small, round dot in the highlight area and then becomes an elongated, inverse ellipse. In other words, it is a line dot with side supports. In the shadows, small round holes occur again. This dot shape was developed for flexographic printing.

Tips and Tricks

In this chapter, you will find some tips and tricks which may be useful for your daily work.

Switching Angles

Sometimes, it is useful to switch the screen angles as you will see in this chapter. In conventional screen systems such as IS Classic, the colors and screen angles are allocated as shown in the table below.

Generally, all applications provide input angles for the colors. These are then converted to the specified output angle with the IS Classic screen system.

Input Angle	Color	Output Angle
15 degrees	cyan (C)	165 degrees
75 degrees	magenta (M)	45 degrees
0 degrees	yellow (Y)	0 degrees
45 degrees	black (K)	105 degrees

Colors C, M, and K which provide more detail are spaced at an angle of 60° or 30°.
The non-defining color Y must be positioned inbetween, spaced at an angle of 15°. Due to the small distance between Y and the adjacent colors, a slight yellow moiré may occur in the overprint with conventional screen systems.
This moiré can be kept to a minimum by switching the screen angles, depending on the motif. This applies generally, irrespective of the way the conventional screens or their approximations were created.

If skin tones are predominant, the angle allocation just mentioned is optimal. Greens (vegetation) have a certain amount of inherent structure and, as a result, moiré is not visible here.

If smooth grayish-greens are predominant, we recommend that the C and M screen angles are switched to avoid moiré occuring between cyan and yellow.

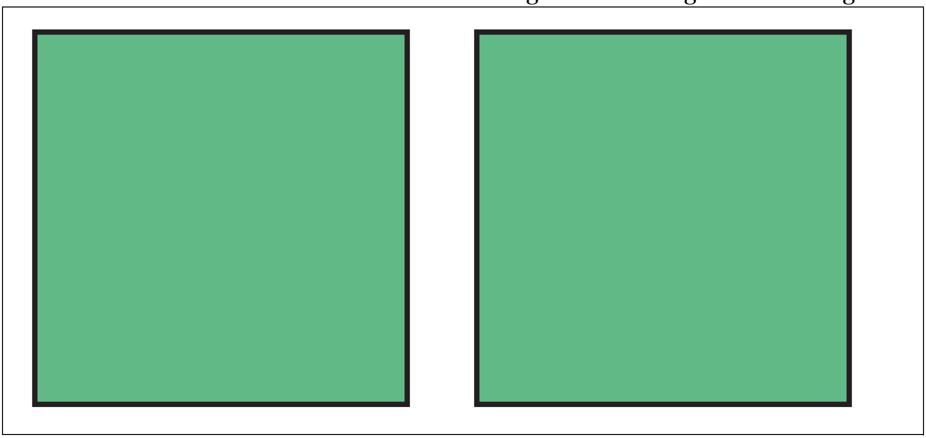
Only the screen angles for C, M and K can be switched. Yellow must always remain at 0°.

The same applies to the other screen systems. Yellow may not be changed to another angle but must keep its angle allocation.

You will find a description of how to switch the screen angles in the relevant user manuals.

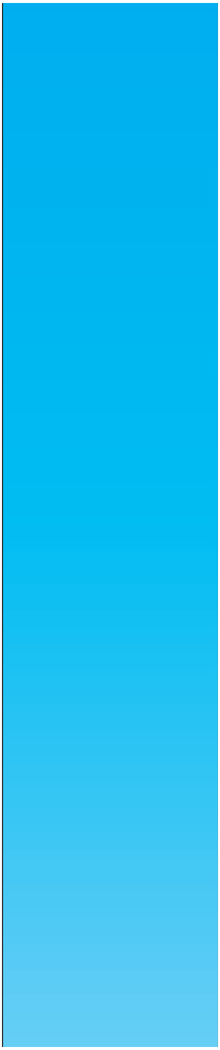
Below you will see two rectangles with a critical hue. These shapes were exposed as follows: IS Classic screen system, 60 screen, 1000 l/cm recorder resolution. The colors in the left rectangle are not switched, those in the right rectangle are.

Colors demonstrating the switching of screen angles:



Left: Rectangle with standard setting
Right: Cyan and magenta switched.

Generated geometric figures were selected for this example as suitable motifs in images proved difficult to find.



Vignettes

Vignettes are particularly suited to demonstrating how finely the human eye can discern objects. It is still able to perceive slight differences in the ink coverage in the dark end of the vignette. To show this, the linear vignette opposite was generated with an 8-bit resolution in QuarkXPress. The ink coverage goes from 50% to 100%. Over a length of 250 mm, this means that a new level starts every 2 mm. The levels are particularly noticeable in the shadows. A top quality imagesetter such as the Herkules PRO reproduces such levels with absolute precision.

Another interesting aspect is optical illusion. The brain processes contours so that the levels appear darker towards the lighter side than towards the darker side of the vignette. A similar effect can also be seen in short vignettes which form the transition from a white area to a black area. Placed directly beside the vignette, white appears whiter than white and black appears blacker than black.

Generating Vignettes

The subject of generating vignettes in various applications is vast enough to fill an entire chapter. However, before we turn to the subject, a word about PostScript. In PostScript Level 2, the processing of 12-bit gray levels is specified, in other words 212 = 4096 gray levels. For performance reasons, most image editing programs only use 8 bits internally, that is 256 levels.

Most image editing applications create a vignette by joining strips of increasing density together. If you are lucky, the 256 density levels are utilized and you have a vignette made of 256 levels with an ink coverage going from 0% to 100%. With this, you have results you can use, especially if the vignettes do not go completely into the shadows or are relatively short.

In many applications, memory and computing time are saved on. As a result, vignettes are created from as few levels as possible. During this process, the application requests the recorder resolution set at the RIP and the screen frequency and calculates the number of possible density levels from this.

Example: With a recorder resolution of 500 l/cm and a 60 screen, the application assumes that a dot is only made up of 8x8 recorder pixels. Consequently, only 64 density levels can be displayed and a vignette with only 64 levels is created. As this is completely insufficient, noticeable breaks occur

Most applications have settings which can be used to deactivate this reduction of the density levels. These settings are often not easy to find in the user interface. Unfortunately, we cannot go into these settings here as the applications are far too numerous. In addition, the settings frequently change from one version to the next.

Really smooth vignettes are created with the DaVinci system which is produced by Heidelberger Druckmaschinen AG. The edges in the vignettes are blurred by means of a trick. In this system, vignettes which come from other applications can be smoothened with the “Replace Vignettes” function. More details can be found in the relevant documentation.

Fairly smooth vignettes can also be created with certain settings in Photoshop.

Breaks can also appear in vignettes through process calibration or a gradation curve. Very steep parts or bends in a process calibration can cause breaks, mainly in short vignettes.

In I.S. screening, multi-dot technology is used as already described in the chapter on screening methods. This ensures that there is always a sufficient number of levels (more than 1000) to be able to reproduce a smooth vignette. Even if the number is reduced to 256 by the PostScript software, these levels even out and, as a result, are not very disturbing.

In other words, breaks in vignettes do not result from the I.S. screening method but always from predefined processes, mainly from the image editing software.

Fill Patterns

In some applications, the user can define fill patterns for figures created. During the output, the PostScript screen mechanism which the user cannot see is used to create the fill pattern.

There are also no problems if you work with the standard PostScript screening in the RIP and the screen frequency is not set to “fixed”. If one of these conditions is not met, the results obtained may not be completely satisfactory.

However, if one of the other screen systems is used, the dot shape selected is always used. A switchover to PostScript screening is only automatic if the screen frequency of the fill pattern is smaller than 20 l/cm (50 lpi). In this way, the user can expose fill patterns which are relatively coarse and still use the top quality of the I.S. screens at the same time.

Seven-color Printing

The subject of seven-color printing will just be touched upon briefly here. A description of how to create the color separation gradations can be found in the scanner manuals, for example, in HiFi Color 3000. We recommend that you work with a strong GCR (Gray Component Removal). In this way, you will only need three different screen angles for seven-color printing.
Black as the dominant color is positioned at 45°. The six chromatic colors cyan, blue, magenta, red, yellow and green are then positioned alternately at 105° and 165°. Screen systems IS Classic, IS Y60° and I Y30° can be used for this.

In this method, each hue is created using only three colors. Black supplies the gray component and when used in conjunction with two adjacent colors, all hues can be created.

A maximum of 10% of a complementary color is added to darken the color. This does not increase the risk of color shift. What you have is practically a colored black-and-white print.

For example, all printable hues can be created between red and yellow with black and these two process colors. The same applies to all other hues. Essentially, only three colors are printed to the same position in the image. This means that in seven-color printing the use of three different screen angles is perfectly adequate without running the risk of color shifts.

The table below is a suggestion for the allocation of screen angles to the colors. Naturally, rational screen systems, Diamond Screening or Megadot can also be used with the respective screen angles.

Color Allocation in Seven-color Printing		
Input Angle	Color	Output Angle
15°	Cyan (C)	105°
45°	Blue (B)	165°
15°	Magenta (M)	105°
45°	Red (R)	165°
15°	Yellow (Y)	105°
45°	Green (G)	165°
75°	Key (K)	45°

Developers/Films

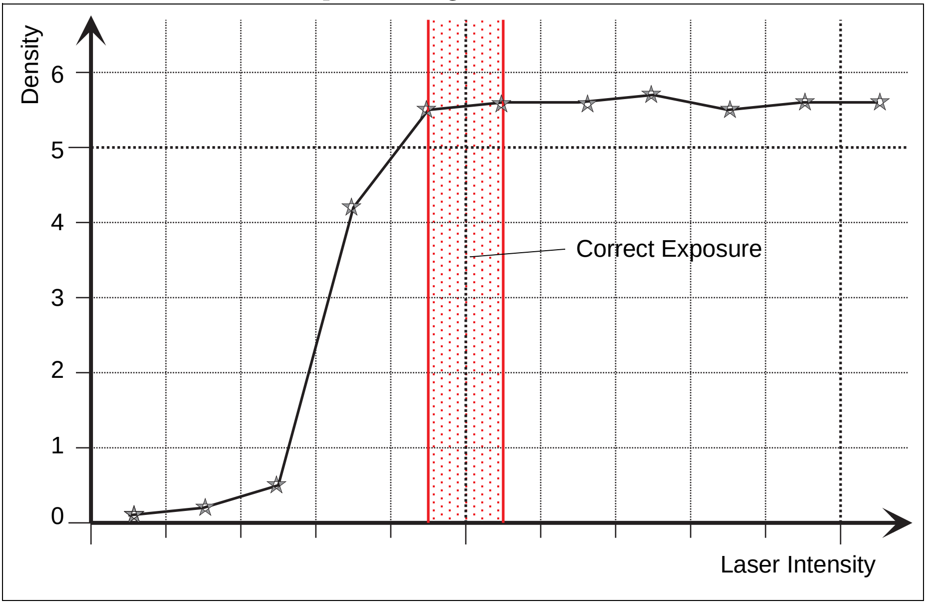
When working with a top-quality recorder, great care must be taken when selecting and handling films, chemicals and processors. Each recorder has a list of suitable films and chemicals. In this respect, it is best to consult the documentation of the manufacturer concerned for details. A few items in general will only be mentioned here.

Hard dot films, in particular, have a high-contrast gradation ("high gamma") and, as a result, create an extremely sharp dot with a high density. It is therefore easy to understand that films where the screen dots have extremely sharp edges are more reliable to work with than films with blurred edges.

For reliable, consistent results, it is important to set the light correctly at the recorder. Just enough light is required to prevent the film from being in the high-contrast part of the gradation curve. Increasing the amount of light only increases the final density of the film somewhat. On the other hand, the effects from overexposure are stronger, the small dots slur where ink coverage is high and non-linearities increase in midtone.

The setting procedures vary accorindg to the recorder and film. They are designed to provide reliable work without overexposure in the simplest way possible.

Gradation curve of a hard dot film with the correct exposure range:



Density

Transmission (T) is an important criterion in the evaluation of films. The transmission of a film or the reflective property of photographic paper or a print can be measured as ink coverage from 0% to 100% or as density (D). Normally, the final density of a film or print is measured in logarithmic units for density and screened areas for ink coverage %. In the densitometer, these properties are only converted on the basis of the formula below. Density is defined as the negative, common logarithm of transmission or reflection:

$$D = -\log10\ (T)$$

The values for transmission, ink coverage and density are illustrated in the table below.

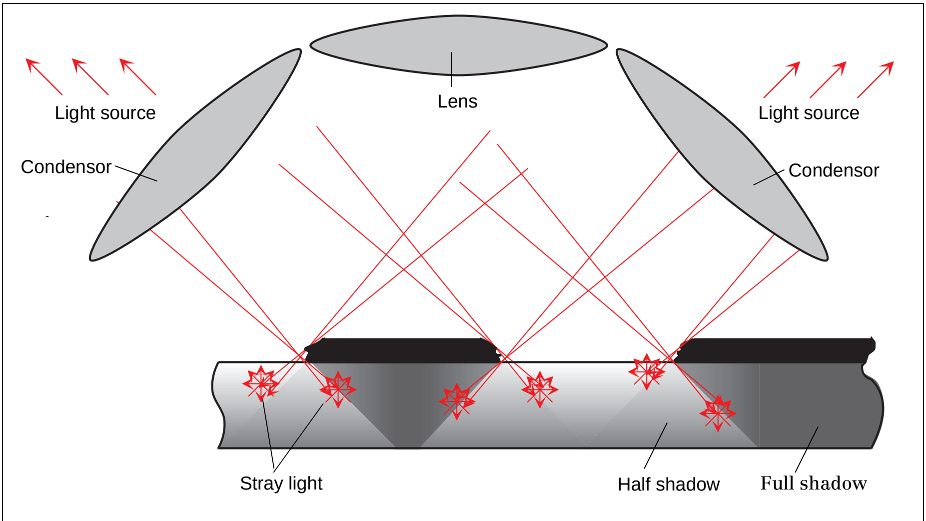
Transmission (T)	Ink Coverage	Density in Print (D)
1	0%	0
0.1	90%	1
0.01	99%	2
0.001	99.9%	3
0.0001	99.99%	4
0.00001	99.999%	5
0.000001	99.9999%	6

With modern recorders, hard dot films can achieve final densities greater than 5. This means that less than 1/100000 of the light is transmitted. With such small amounts of light, it is easy to understand that measuring errors caused by noise in the densitometer, ambient light, stray light on dust and minute pores in the film can influence the result considerably. Some densitometers, for that reason, confine what is displayed to a maximum value. Fluctuations where density is greater than 5 should not be taken too seriously.

More or less major errors cannot be excluded from measurements.

If the reflective property of a print or phototgraphic paper is measured, measuring errors are generally caused by the effects from light reflection. How these systematic errors occur is depicted in the graphics below. There are also measuring errors which are incidental, for example, from stray light on dust on the photographic paper or print.

Effects from light reflection in the reflective densitometer:



The diagram above shows how light reacts in the measuring head of a densitometer. The original is illuminated by condensor lenses attached to the side. The diffusely reflected light is projected onto a photo cell and measured by means of a central lens. Light mirrored on the surface does not fall onto the lens in this configuration. In the diagram above, the lenses are much too small compared to the screen dots and are too near to the surface of the paper.

Light reflection effects occur mainly due to the fact that light is not dispersed directly on to the surface but penetrates the paper and is only dispersed back from there. Part to the light is scattered among the screen dots and absorbed at the colored parts. It is caught below the screen dots. Half-shadow appears around the printing dots. This half-shadow causes a dot gain of some µ. That does not sound very much but with a 60 screen this causes a dot gain of approximately 12% in the midtone. If screened films are copied to photographic paper, the presence of light reflection effects should be taken into account when measuring the film.

Dot gain measured in the print can essentially be traced back to effects of light reflection. Such effects must not be taken into account with printing characteristics since they are already contained there implicity.