Handbook
for screen printers

Published by:

SEFAR
Printing Division

February 1999

Foreword

Welcome to this, the first edition of the Sefar Screen Printing Handbook.

It is intended as a comprehensive, up-to-date reference work for screen printers. Written by and for screen printers, it aims to cover all aspects of the screen printing applications.

WE SHARE OUR KNOWLEDGE: This is a cornerstone of the Sefar Group's business philosophy. In this book, we offer a comprehensive body of reference material to screen printers. We have always considered customer feedback essential to our success as mesh manufacturers. This handbook is an ideal reference to our screen printing courses and customer-specific training programs.

We have gathered the knowledge and experience of Sefar's application technologists. We would like to thank everyone who contributed to this book and provided text and illustrations.

Sefar

Printing Division

›ntents

1. Monofilament screen printing mesh

Standard polyester mesh makes ideal stencil material for screen printing. Precision weaving techniques, using state-of-the-art equipment optimized for screen printing applications, results in excellent mesh quality.

Polyester mesh woven from high-viscosity polyester is a further development of standard polyester mesh. The material's reduced elasticity enhances the already good properties of standard mesh. These mesh types offer increased process reliability, and significantly higher tensioning that is retained over large print runs and long periods of time.

Polyamide mesh (nylon) has exceptional mechanical durability. This makes polyamide highly suitable for printing abrasive media (ceramic colors, reflective inks). The mesh's high elasticity makes it easier to print uneven surfaces (e.g. shaped objects).

Stencil films and emulsions adhere better to polyamide mesh than normal polyester mesh.

Note: This book uses the abbreviations PET for polyester, PA for polyamide.

1.1 Raw materials

Physical properties

The raw materials generally used for screen printing mesh – "stencil carriers" according to DIN 16610 – are monofilament chemical fibers made of synthetic polymers.

The fibers most frequently used are:

– Polyamide, abbreviated to PA 6.6

– Polyester, abbreviated to PET

They both belong to the group of polycondensation or polymerisation fibers.

The group to which they belong governs the fiber's physical properties.

Polyester PET

The main properties of polyester fibers are:

– high resistance to stretching

– good mechanical durability

– good abrasion resistance

– high resistance to light
– insensitivity to climatic factors

Other properties are listed in the table "Fiber properties” below.

Polyamide PA (Nylon)

Polyamide fibers are excellent in the following respects:
– very good mechanical durability
– high abrasion resistance
– good surface-tension characteristics
– high elasticity
– good dimensional recovery characteristics (100 % following 2 % elongation)

Other properties are listed in the table ”Fiber properties” below.

Fiber properties

	Polyamide PA 6.6 (nylon) monofilament	**Polyester PET monofilament**
Specific gravity	1.14	1.38
Tensile strength in daN/mm^2 (dry)	41 - 67	45 - 75
Rel. tenacity (wet) %	90 - 95	100
Elongation at break % - dry - wet	 20 - 35 25 - 40	 15 - 30 15 - 30
Moisture absorption % at 68°F and 65% rel. humidity	3.5 - 4	0.4
Melting point °F	477 - 487	464 - 500
Softening point °F	437 - 455	428 - 464
Temperature resistance °F (approximate limiting temperature under dry conditions)	Color change from white to yellow. The degree of change and strength reduction depends on the temperature and reaction time.	Dry heat up to 302°F Continuous exposure
Resistance to light and weather	Low to average	Good to very good
Abrasion resistance	Very good	Good

Chemical resistance

	Polyamide PA 6.6 monofilament	Polyester PET monofilament
a) Acids generally	Limited —poor	good
Sulphuric acid Hydrochloric acid Nitric acid	Reduced resistance or dissolution, dependent on concentration, temperature and reaction time	Unaffected at low concentrations, temperatures and reaction times
Formic acid	Soluble	Unaffected
Ethanoic acid	Good, temperature-dependent	Unaffected
b) Alkalis generally	Good, temperature-dependent	Limited, poor
Sodium hydroxide Potassium hydroxide	Unaffected at normal room temperature, weakening at higher temperatures	Soluble at higher temperatures, concentrations and reaction times
c) Solvents generally	Good resistance to common screen printing solvents	Good resistance to common screen printing solvents

Remarks:

Polyamide

Sensitive to acids
Fibers are either weakened or destroyed, depending on concentration, temperature and reaction time.

Good resistance to alkalis.

Polyester

Sensitive to alkalis
Fibers can be weakened to the point of destruction, depending on concentration, temperature and reaction time.

Highly resistant to inorganic acids.

1.2 Physical mesh properties

Screen printing mesh with differing properties can be produced from the same fiber group by modifying the fiber and/or mesh manufacturing processes.

In any screen printing application, the elongation characteristics of the screen printing mesh are crucial.

Elongation characteristics govern:

- tensioning procedure
- mesh strength
- mesh stability

Elongation characteristics have a direct influence on usage characteristics such as:

- register and dimensional precision of the printed image
- snap-off behavior
- conformance with the object to be printed, important when the substrate has an uneven or irregular surface
- selecting a mesh type appropriate to the requirements of the printing parameters

Having decided which fiber type to use, printers must then choose between polyamide or polyester mesh.

Polyamide mesh Nitex

Polymide meshs were the first and most enduring monofilament chemical fibers to be used in screen printing. Although a relatively old technology, polyamide meshs still remain viable in certain areas of today's screen printing industry, thanks to their desirable properties:

- good mechanical durability
- good abrasion resistance
- good surface-tension properties
- relatively high elasticity

Modified polyamide mesh PA 2000

This type of mesh combines the properties of regular polyamide mesh – good mechanical durability, abrasion resistance, and surface tension properties – with lower elongation.

The benefits:
Improved snap-off and ink release, with sufficient elasticity to conform with uneven substrates.

Polyester mesh

The classic stencil substrate for screen and textile printing. Correctly handled, it can be used in a wide variety of applications.

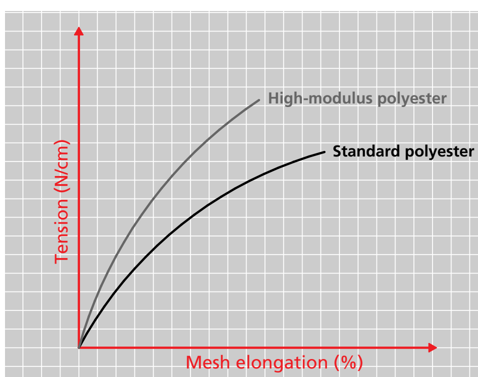
Property	Practical benefits
Low elongation	• Good tensioning behavior • Good snap-off behavior • Good registration accuracy
High mechanical durability and chemical resistance	• Suitable for long print runs • Good reclaiming and re-use characteristics
Smooth fiber surface	• Very good ink penetration • Fast ink release → high speed printing • Good reproduction of detail
Resistant to changes in climate (humidity / temperature)	• Good dimensional stability • Rapid drying after cleaning, coating and developing

Modified polyester mesh Pecap LE

Monofilament polyester mesh with reduced elongation, also known as "high-modulus mesh", is distinguished from regular polyester mesh by its low elongation and mechanical resistance.

Property	Practical benefits
Very low elongation	• Able to withstand high tensions • Good lift-off and ink release characteristics with minimal off contact • Increased registration accuracy • Consistent accuracy over long print runs • Modest reduction in tension with use • Longer production life

1.3 Elongation characteristics of polyester mesh



Force/Elongation characteristics of screen printing mesh manufactured by Sefar AG from monofilament synthetic fibers.

The elongation characteristics are vital to the performance of the stencil system. This is illustrated in the force/elongation diagram above.

The graph shows the relationship between the tensioning force and the resulting mesh elongation, including the force and elongation just before the sample tears. Tensioning tests are an integral part of SEFAR's quality control, and are conducted using tension testing machines under constant controlled conditions.

1.4 Geometry of screen printing mesh

Mesh geometry describes all two and three-dimensional aspects of the mesh's structure.

The basic factors in mesh geometry are mesh count and thread diameter.

Mesh count is specified as the number of threads per inch

The thread diameter is specified as a nominal value, referring to the diameter of the unwoven thread.

When selecting mesh for a particular application, mesh geometry is of greater importance than the elasticity character.

Mesh geometry directly affects:

- printability of fine line and halftone images
- edge definition in the print
- ink release characteristics
- maximum printing speed (in conjunction with ink viscosity)
- thickness of the ink volume
- ink consumption
- ink drying

The following values, listed in technical datasheets, such as

- mesh opening in µm, abbreviated to (w)
- mesh opening in %, abbreviated to (ao)
- mesh thickness in µm, abbreviated to (D)
- theoretical ink volume in cm^3/m^2, abbreviated to (Vth)

are all derived from the mesh count (Fn) and the thread diameter (d).

The fundamental geometrical unit is the mesh pitch (t).

Pitch (t) is the sum of one mesh opening and thread diameter (t = w + d). This value is calculated as follows: t = 25,400/Fn.

The flat surface of a mesh is the result of weaving perpendicular warp and weft threads. A high quality mesh is characterised by extremely close tolerances for both the overall mesh count (Fn), as well as mesh counts in the warp and weft directions.

Sefar products guarantee the closest mesh geometry tolerances; these are published in the technical datasheets.

Mesh count and thread diameter

The terms ”mesh type“ or ”mesh specification“ are similar descriptions of the mesh count per inch, together with the thread diameter.

Example: 305-34 indicates 305 threads per inch, each with a nominal thread diameter of 34 µm.

The nominal thread diameter refers to the diameter of the unwoven thread.

”Mesh type“ is a relatively new term that replaces the widespread SL/S/M/T/HD nomenclature.

New nomenclature	Old nomenclature
305-31	305 S
305-34	305 T
305-40	305 HD
380-27	380 SL

Mesh type description

W = **W**hite

Y = **Y**ellow

CY = spun dyed, yellow

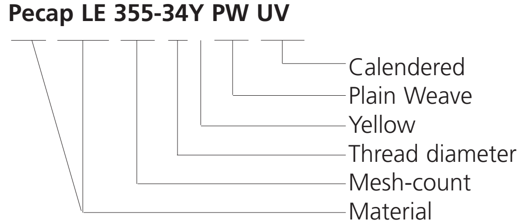
PW = **P**lain **W**eave

TW = **T**will **W**eave

UV = One Side Calendered

Example:

Pecap LE 355-34Y PW UV



Mesh number		Weave	Tolerance of mesh count	Mesh opening	Thread diameter nominal	Open area	Mesh thickness	Tolerance of Mesh thickness	Theoretical ink volume	Weight of mesh
cm	inch		+/- n/inch	μ	μ	%	μ	+/- μ	cm³ / m²	g / m²
120-31W PW	**305-31W PW**	**1:1**	**7.6**	**49**	**31**	**35.0**	**49**	**3**	**17.2**	**26**
120-31Y PW	**305-31Y PW**	**1:1**	**7.6**	**49**	**31**	**35.0**	**49**	**3**	**17.2**	**26**
120-34W PW	**305-34W PW**	**1:1**	**7.6**	**45**	**34**	**29.6**	**55**	**3**	**16.3**	**34**
120-34Y PW	**305-34Y PW**	**1:1**	**7.6**	**45**	**34**	**29.6**	**55**	**3**	**16.3**	**34**
120-40W PW	**305-40W PW**	**1:1**	**7.6**	**37**	**40**	**20.1**	**65**	**3**	**13.0**	**44**
120-40Y PW	**305-40Y PW**	**1:1**	**7.6**	**37**	**40**	**20.1**	**65**	**3**	**13.0**	**44**
150-27Y PW	**380-27Y PW**	**1:1**	**10.2**	**36**	**27**	**28.6**	**41**	**2**	**11.7**	**26**
150-31W PW	**380-31W PW**	**1:1**	**10.2**	**32**	**31**	**23.3**	**47**	**2**	**10.9**	**32**
150-31Y PW	**380-31Y PW**	**1:1**	**10.2**	**32**	**31**	**23.3**	**47**	**2**	**10.9**	**32**
150-34W PW	**380-34W PW**	**1:1**	**10.2**	**23**	**34**	**12.1**	**55**	**3**	**6.6**	**42**
150-34Y PW	**380-34Y PW**	**1:1**	**10.2**	**23**	**34**	**12.1**	**55**	**3**	**6.6**	**42**
150-34W TW	**380-34W TW**	**2:1**	**10.2**	**26**	**34**	**15.4**	**62**	**3**	**9.6**	**42**
150-34Y TW	**380-34Y TW**	**2:1**	**10.2**	**26**	**34**	**15.4**	**62**	**3**	**9.6**	**42**

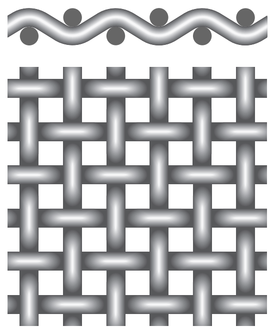
From the Technical data sheet for Pecap LE

Weave type

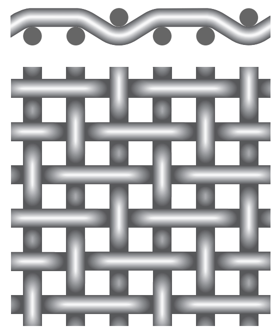
The mesh type is specified along with the weave type. This describes the pattern in which the weft and warp fibers cross over each other, and is expressed as a weave number.

Screen printing meshs are either plain or twill weave. Plain weave mesh types are 1:1 weaves.

Various types of twill weaves have differing weave numbers e.g. 2:1, 2:2 or 3:3.



Plain 1:1 = PW



Twill 2:1 = TW

Mesh opening

Mesh opening (w) is the spacing between adjacent warp or weft threads, and is measured perpendicular to the plane of the mesh.

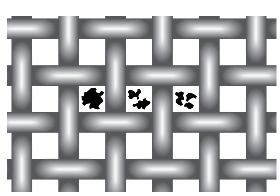
Mesh opening governs:

– the maximum particle size to be used in a screen printing ink

Mesh opening affects:

– the level of printed detail in line and halftone artwork
– ink release characteristics
– the thickness of the ink volume

Note: For adequate ink penetration, the maximum particle size (p) of the screen printing ink must be smaller than 1/3 of the mesh opening.



Resolution characteristics

"Resolution" refers to the level of printed detail in line and halftone artwork that a given mesh is capable of reproducing. It is governed primarily by the mesh count, and the relationship of thread diameter to mesh opening.

Examining the relationship of thread diameter to mesh opening (w) more closely, screen printing mesh fall into the following categories:

a) Mesh opening greater than thread diameter ($w > d$)
Pecap LE 380-27PW w =36µ

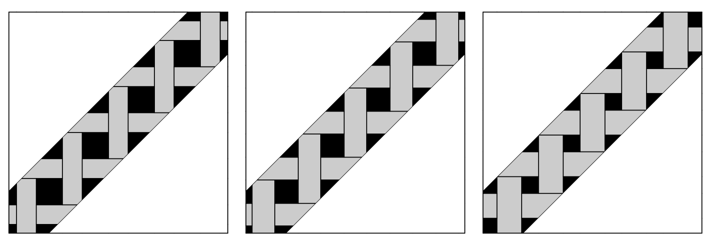
b) Mesh opening comparable to thread diameter ($w \cong d$)
Pecap LE 380-31PW w =32µ

c) Mesh opening less than thread diameter ($w < d$)
Pecap LE 380-27PW w =23µ

In general, mesh types where the mesh opening is greater than the thread diameter are capable of higher resolution than mesh types where the opposite is true.

Next to the relationship of thread diameter to mesh opening, the thread diameter itself also affects the printable dot/line size.

Secondary factors in the printability of fine line and halftone artwork are the flow, viscosity, and rheology of the screen printing ink.



Pecap LE 380-27 PW Pecap LE 380-31 PW Pecap LE 380-34 PW

The theoretical resolution capability (A_{th}) for a given screen printing mesh can be estimated from the following formula:

$$\mathbf{A}_{th} = \sqrt{2} * t * d/w$$

$$(t = w + d)$$

Table: Theoretical resolution (A_{th}) for a variety of screen printing mesh types

Mesh type Fn-d_1	Mesh opening w in µm	d_2/w	A_{th} µm
255-40	55	0.80	96
280-34	52	0.75	78
280-40	44	1.06	105
305-31	48	0.73	71.6
305-34	43	0.93	84.4
305-40	34	1.44	117.7
355-31	35	1.03	81.6
355-34	28	1.54	100.8
380-27	35	0.91	66.8
380-31	30	1.23	86.3
380-34	25	1.54	119.
420-27	28	1.18	73.7
420-31	23	1.65	103
460-27	23	1.43	85.0

Key:

A_{th} = *Theoretical resolution*

Fn = *Mesh count*

d_1 = *Nominal thread diameter*

d_2 = *Woven thread diameter*

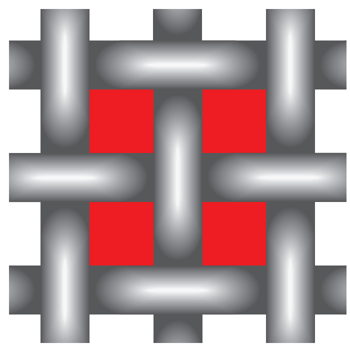
w = *Mesh opening*

The theoretical resolution value of a mesh should be taken as a relative guideline for better understanding of geometrical factors on the relationship between mesh number, thread diameter and mesh opening.

Open area, α_o (open mesh area in %)

The sum of all the mesh openings over the total area. A mesh with an α_o of 30.5% has an open mesh area of 30.5%, and a closed, impervious area of 69.5%.

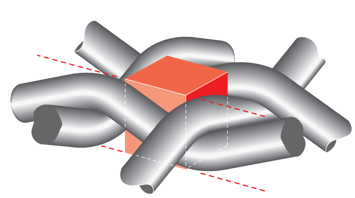
α_o % is one of the variables used to calculate the theoretical ink volume.



Theoretical ink volume Vth cm³/m²

This value is calculated from the open area and mesh thickness. The volume of the open mesh governs the effective amount of ink that a screen printing mesh can accept. The calculated effective ink volume is higher than, but proportional to, the theoretical ink volume.

Under realistic conditions, the degree to which a mesh is filled with ink depends on the squeegee speed, squeegee blade characteristics – hardness, angle, and finish – and the consistency of the ink itself. Given the difficulty of calculating a value based on so many variables, theoretical ink volume provides a more practical alternative for determining ink consumption and the thickness of the printed volume.



Given optimally filled mesh and clean ink release, the thickness of the wet printing ink deposit can be estimated from the theoretical ink volume:

$$\textbf{Theoretical ink volume cm}^3/\textbf{m}^2 = \frac{\textbf{ao * D}}{\textbf{100}}$$

A mesh with a theoretical ink volume of 18 cm^3/m^2 produces an estimated printed layer with a thickness (when wet) of 18 µm.

Basic ink consumption (Mf) is then estimated by:

$$\mathbf{m^2/Lt = \frac{1000}{Vth}}$$

The relative accuracy of the estimated value may be improved by incorporating factors to compensate for the absorbtion of the printing stock and the percentage thinning of the screen printing ink.

Compensation factor S for porosity of the printing stock:

S for highly porous printing stock	= 0.5
S for slightly porous printing stock	= 0.8
S for non-porous printing stock	= 1.0

Compensation factors for ink thinning percentage (V)

V	0%	=	1
V	5%	=	1.05
V	10%	=	1.10
V	15%	=	1.15
V	20%	=	1.20

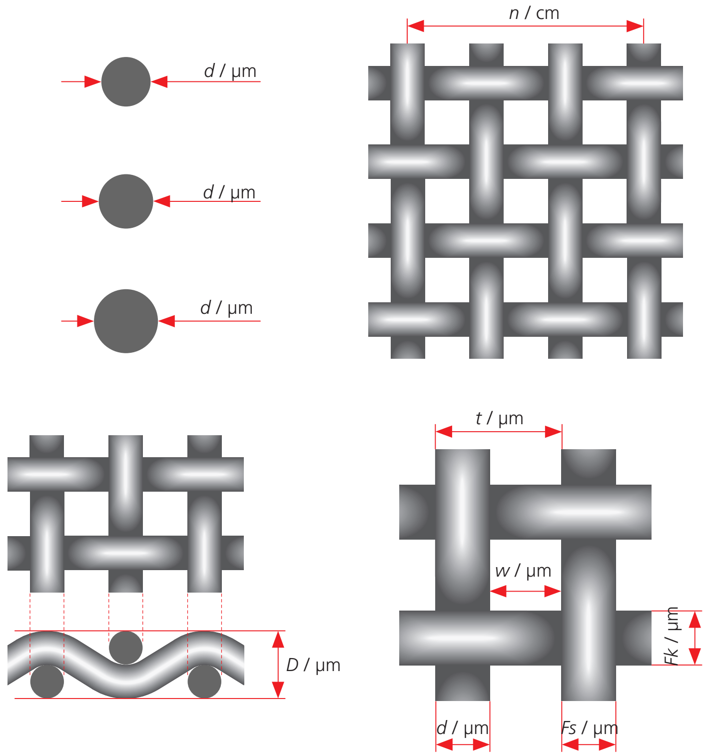
etc.

Taking all these factors into account, the approximate ink consumption (Mf) can be derived from the screen printing mesh's theoretical ink volume using the following formula:

M2/Lt = (theoretical coverage) * S * V

$$= \frac{1000}{V_{th} * S * V}$$

Mesh geometry summary



Key:

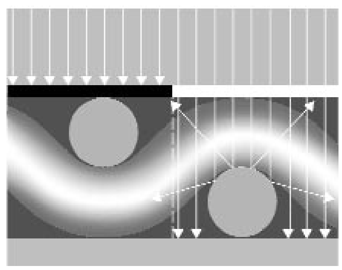
D	=	*Mesh thickness*
d	=	*Thread diameter*
Fk	=	*Warp threads*
Fs	=	*Weft threads*
n	=	*Mesh count*
t	=	*Pitch = w + d*
w	=	*Mesh opening*

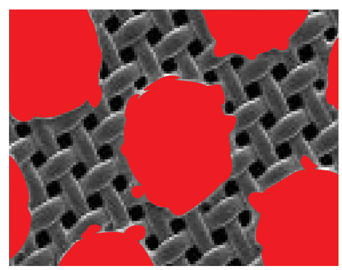
1.5 Colored screen printing mesh

By exposing a direct stencil to light, the illuminated areas become hardened. Light rays striking the white fibers of the mesh are reflected, and scatter under the black edges of the film.

Light is also conducted through the fibers themselves, leading to yet more under cutting.

The results are unsharp printed edges, causing color shifts in multicolor halftone artwork. There is a reduction of the open printing areas, particularly in fine detail work. To keep this phenominon under control, it is necessary to calculate exposure times leading to proper exposure.

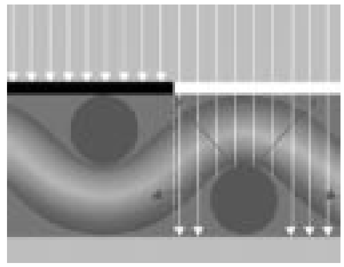
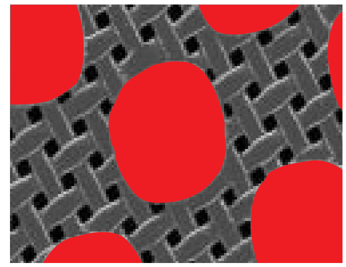




White mesh

Emulsions and films are sensitive in the UV range, from approximately 350 to 420 nanometers. To be effective, light scatter protection must absorb UV light over this wavelength range. The obvious choice in achieving this is to use the complementary color, which by definition absorbs the desired wavelengths. Absorption tests show that the most effective absorber in the 350 – 420 nanometer range is a warm yellow color.

When UV light strikes a yellow fiber, only yellow light is reflected – and this has no effect on the emulsion. This is why it is advisable to work with emulsion in yellow light. Emulsions are sensitive only to blue UV light. The results are pin-sharp edges, and open details. Also, because light scatter is no longer an issue, it is now possible to give exposure times that thoroughly harden the emulsion. In general, exposure times on dyed SEFAR mesh are 75% – 125% longer than on their plain white counterparts due to less light scatter of blue UV light; this results in tougher, more durable stencils. Generous overexposure latitude reduces the risk of underexposure.

Dyed mesh

Dyed mesh should always be chosen for printing the finest lines, text and halftones when maximizing stencil durability.

1.6 Calendered screen printing mesh Pecap UV

Screen printing inks contain solvents that evaporate during the drying process, thus reducing the thickness of the ink volume.

UV-cured ink, by contrast, contains very little or no solvents. This means that curing does not significantly reduce the thickness of the ink volume.

The high ink film left by UV-cured inks often produces problems:

- UV light does not adequately penetrate a thick ink layer, especially when it is heavily loaded with pigment. The ink is incompletely cured as a result.
- Multicolor halftone printing:
  If the first two colors are too thickly layered, there is barely space for the third and fourth colors between or on top of the points left by the first two. This results in color shifts, smeared print, and moiré effects.

Recent years have seen major progress in weaving technology. This makes it feasible to produce even the finest meshs in a 1:1 weave. The resulting trend is towards increased use of finer, uncalendered meshs that offers increased printing resolution and better ink control characteristics. For this reason, the range of calendered mesh types have been reduced.

The current range still includes the following mesh numbers, available with a maximum width of 81 inches:

Pecap LE 7 - 355-34Y PW UV

Pecap LE 7 - 380-31Y PW UV

Pecap LE 7 - 380-34Y PW UV

Pecap LE 7 - 420-31Y PW UV

Pecap LE 7 - 420-34Y TW UV

Pecap LE 7 - 460-31Y TW UV

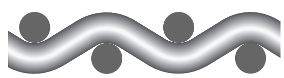
These mesh types are suitable for printing with UV inks and lacquers.
Pecap LE UV is calendered on one side of the mesh.
The calendered side is shiny, the other side is dull.

There are two techniques for reducing the ink deposit:

1. By stretching the mesh with the shiny surface facing the squeegee, UV mesh reduces the ink deposit by around 10 – 15% compared to uncalendered mesh.

2. If the shiny surface is stretched facing the substrate, the ink deposit is reduced by around 15 – 25%.

The degree of ink volume reduction depends on a variety of additional factors in the printing process, particularly the ink's rheological characteristics, which vary depending on the color. It is therefore impossible to give exact figures.

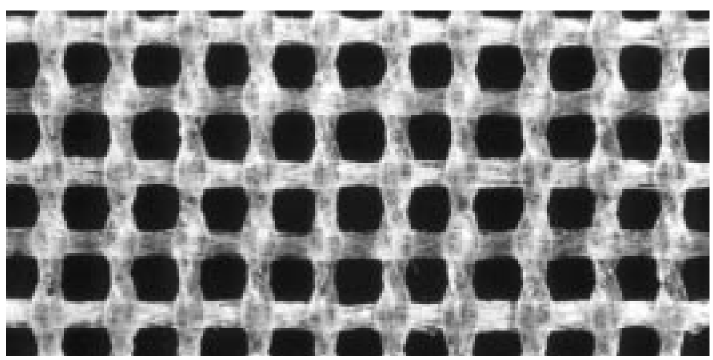
Mesh cross-sections:	Comparative ink deposit:
	
Regular mesh	*100%*
	
Calendered side = squeegee side (RK)	*approx. 10–15% reduction*
	
Calendered side = substrate side (DK)	*approx. 15–25% reduction*

1.7 History and development of screen printing mesh

Several hundred years separate the first stencils made from human hair, and contemporary high-precision screen printing materials based on modified synthetic fibers. Despite this, screen printing is a relatively new printing technique, the first documented appearance being a patent submission from 1907 in which Samuel Simons recommended silk gauze (used to sieve flour) as a stencil material. Shortly thereafter, silk weavers began manufacturing plain weave mesh especially for screen printers, allowing finer printing and improved ink control.

The rise of synthetic fibers not only improved screen printing quality, it also increased the range of potential applications. Serigraphy, originally used by artists, became an industrial printing technique. Research and development in the weaving industry produced continual advances: meshs with up to 508 threads per inch, widths up to 143 inches, and extraordinarily high tensioning capability, opened radically new vistas for screen printing in all branches of industrial manufacturing.

The silk gauze recommended by Samuel Simons was woven from selected multifilament silk yarn. To prevent threads from sliding and blocking the mesh as the flour was sieved, a special technique called twill weaving was used:



Silk gauze, multifilament

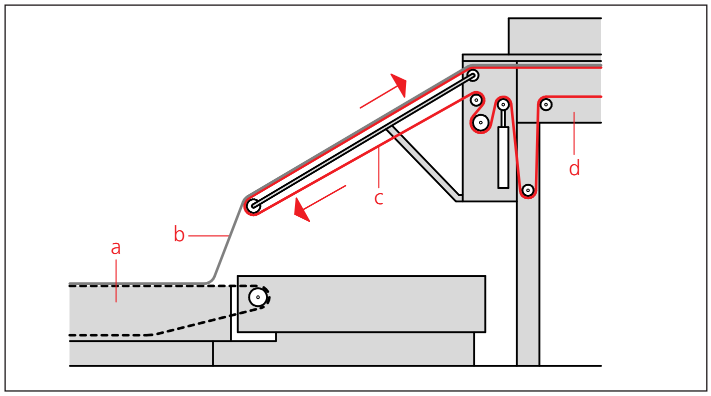
The first mesh specially developed for screen printing was also made from multifilament silk yarn, but plain woven. The mesh count could thus be increased to 230 threads per inches.

The first synthetic yarns were likewise multifilament, plain woven, but considerably easier to stretch than silk. Furthermore, they were insensitive to water and resistant to chemical attack. These properties represented a breakthrough, because they allowed screen printing technology to be used with every imaginable ink system and printing stock.

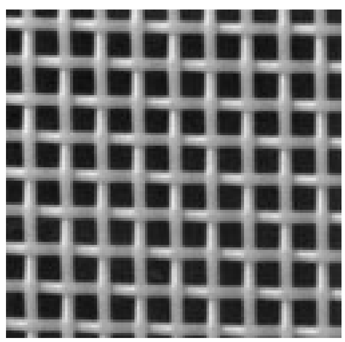
The spinning industry's success in manufacturing monofilament yarns opened the way for a further step in screen printing development. Monofilament yarns can be manufactured in considerably thinner and more consistent diameters than their multifilament counterparts. Thus, mesh with up to 508 threads per inch could be manufactured, with no loss of mesh opening compared to multifillament mesh. This opened up entire new markets to screen printing, with applications in electronics, ceramics, packaging, CD labels, etc.

Despite satisfying growth in the screen printing industry, research and development continues apace. New materials are being tested, along with varied mesh treatments and novel weaving techniques. The screen printing industry can continue to look forward to new generations of screen printing meshes, able to keep pace with increasing demands and expectations.

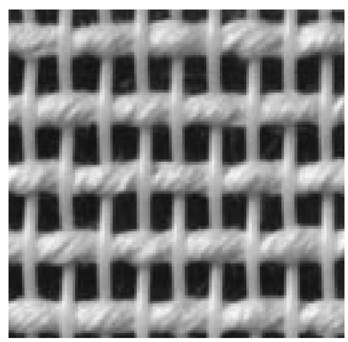
1.8 Conveyor belts for textile printing dryers



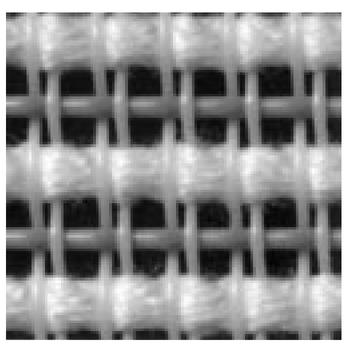
Conveyor belt:
a = Printer table
b = Printed stock
c = Conveyor
d = Dryer



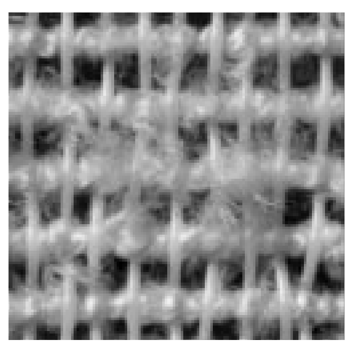
PET 1000 HD



PET Mono-Multi



PET Mono-Multi PLUS



PET Soft

Conveyor belts made of strong polyester monofilament, for example PET 1000–HD, have the following advantages:

Air-current pervious – fresh air reaches all sides of the conveyed goods. The benefits:

- lower drying temperatures are possible
- higher running speeds are possible
- energy savings
- permissible temperatures up to 300 ºF
- no squeezing of the conveyed goods
- anti-static treatment possible
- good running characteristics
- minimal soiling, easy to clean.

Belts are available with a variety of closures (mainly of the snap variety), or stitched together as an endless belt.

Belts are supplied with either a woven or welded edge trim. Both variants can be hemmed with reinforcing tape to protect against fraying.

For temperatures above 300 ºF we recommend conveyor belts made of PTFE coated glass fiber.

Textile endless belts are subject to a certain degree of stretching and elasticity. They should therefore be tensioned over compensation rollers.

Please address questions and queries to:

SEFAR AMERICA INC.
Filtration Division
111 Calumet Street
Depew, NY 14043

Tel. 716 683-4050
Fax 716 683-4053

Internet: http://www.sefaramerica.com

2. Screen printing frames

A screen printing frame is constructed and designed to hold a tightly stretched piece of mesh. Screen printing frames should be as resistant as possible to mechanical deformation, both during stencil-making and during the printing process. The surface should also be resistant to chemicals used in stencil-making, printing inks, solvents and cleaning materials.

Metal frame sections must be welded to lie perfectly flat, and straightened where necessary. Warped frame sections are a considerable nuisance when printing, and lead to registration errors.

2.1 Materials used for screen printing frames

Wooden frames

Wooden frames are easily handled, especially the small wooden frames for container printing. They should not be used, however, for precision register prints. Wood swells and shrinks, often within a few hours, due to fluctuating humidity and temperature. Wooden frames have a shorter life than metal frames; they warp in the course of time and no longer lie flat.

Painting the wood with a two-component lacquer protects it from water and solvents.

Metal frames

Metal screen printing frames are typically constructed from hollow sections. Aluminum and steel are the metals most commonly used to make screen printing frames.

Aluminum is 2.9 times more flexible than steel of similar cross-section. To give aluminium comparable strength, the cross-sectional area must be enlarged, the section walls thickened, or an alternative section profile chosen.

Aluminum frames

Aluminum's specific gravity (approximately 2.7) means that even very large frames may easily be handled. However, larger frames must be designed with increased cross-sectional area and reinforced walls. Aluminum frames do not rust, but are less resistant to alkalis and acids.

Advantages:

- can be used to stretch all kinds of mesh
- light weight
- wide choice of cross sections
- low-cost
- good corrosion resistance
- easily cleaned

Disadvantages:

- less robust than steel

Steel frames

Given the good rigidity of steel frames, the cross-section can be smaller than a comparable aluminum frame. A major disadvantage, especially with large frames, is their associated weight (specific gravity of steel approximately 7.8).

Regular steel frames tend to rust, and require appropriate treatment (galvanising or painting).

Advantage:

- low-cost

Disadvantages:

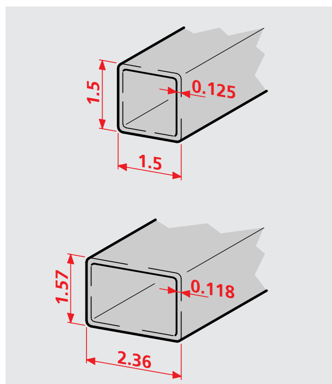
- susceptible to corrosion
- heavy
- require repainting before re-use (depending on adhesive).

2.2 Sections

Next to the material used, the type of section and the wall thickness are decisive factors influencing the dimensional stability of screen printing frames.

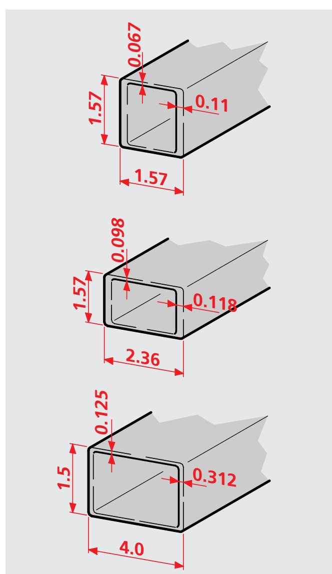
We distinguish between rectangular and special sections. All values are inches.

Rectangular sections

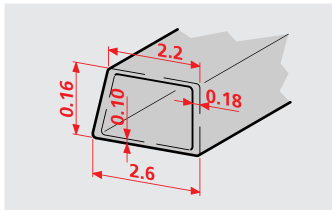


Sections with 4 identical wall thicknesses

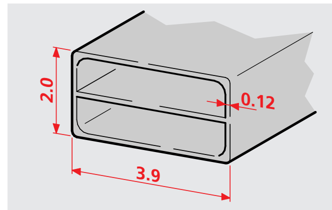
Special sections



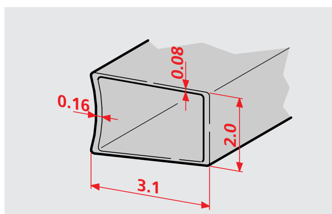
Sections with reinforced vertical walls



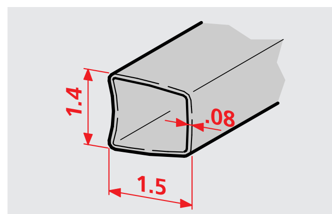
Section with sloping inner edge



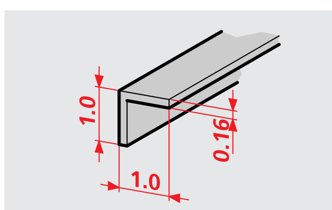
Section with inner support



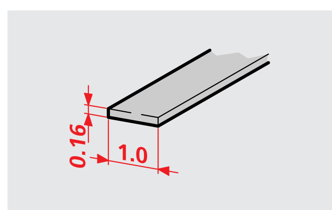
Section with concave edge



Section with concave edge, tapered to the outside (for textile printing)



Special-purpose L-section (e.g. for object printing)

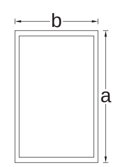


Flat steel strip for CD frames

Fame Profile Dimensions			Up To 25N/cm		25N/cm +	
Model	Outside Dimensions	Wall Thickness	Maximum Length (a)	Frame Size Max (a+b)	Maximum Length (a)	Frame Size Max (a+b)
#79	.79" x .79"	.079"	12"	21"	9"	15"
#118	1.18" x .79"	.079"	18"	32"	12"	20"
#118/157*	1.18"1.57"x 1.18"	.063" x .118"	24"	43"	21"	39"
#150	1.50" x 1.50"	.0625"	21"	39"	18"	32"
		.125"*	31"	57"	27"	49"
#157*	1.57" x 1.57"	.067" x .110"	27"	51"	24"	45"
#236*	2.36" x 1.57"	.098" x .118"	45"	85"	31"	55"
#300*†	3.00" x 1.50"	.125"	60"	113"	45"	83"
#400*†	4.00" x 1.50"	.125"	105"	198"	60"	108"
#400 HD*†	4.00" x 1.50"	.125" x .312"	125"	233"	105"	193"

** Welded and pressed inserts available upon request*

† Frame profiles with 3 and 4" widths require special construction. Allow more than 72 hours for order shipment.



2.3 Frame size

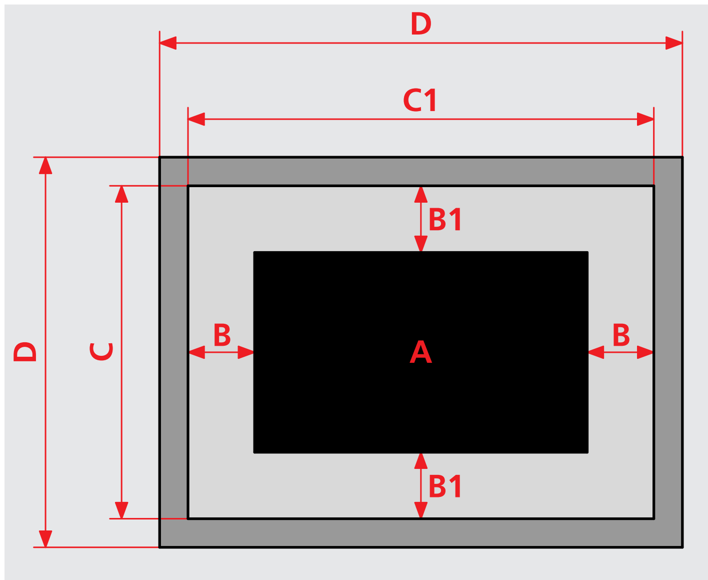
The choice of frame size depends on the desired printable area and the type of printing. There should always be an adequate zone reserved outside the printable area, for use as an ink well.

In machine printing, the squeegee motion is usually in the direction of the frame width; in other words, contrary to the usual practice in hand printing. The horizontal and, in particular, the vertical distances between the frame and printable area (the ink rest) has to be determined for every type of machine. Too small of an ink well can lead to registration difficulties and poor print quality. *The image size, frame size, and the size of equipment must all be compatible and should be determined through individual trials.

In textile printing, the size of the printable area and the frame must be adapted to the squeegee system, and set up in accordance with the machine manufacturer's instructions.

In contrast to graphic screen printing, textile printing is generally done in "contact", i.e. there is no physical separation between the stencil and the printing stock. (See the chapter on printing.)

Recommended frame sizes



A Printable area in inches	B/B1 Free mesh side/top in inches	C/C1 Frame outside dimensions in inches	Aluminum sections and wall thickness in inches	Aluminum sections with various wall thicknesses in inches
8.5 x 11	6.0 / 6.0	15.25 x 18.75	1.50 x 1.50	1.57 / 1.57
11 x 17	6.0 / 6.0	18.75 x 27.25	.0625 - .125	.067 x .110
17 x 22	6.0 / 6.0	28.3 x 31.5		
24 x 36	6.5 / 6.5	40.0 x 56.25		1.57 x 2.36
34 x 44	7.25 / 7.25	53.25 x 67.5		.098 x .118
47 x 63	7.75 / 7.75	63 x 79		1.57 x 2.36
				.098 x .118
55 x 71	8.5 / 8.5	71 x 87	3.0 x 1.5	
			0.125	
63 x 83	9.8 / 9.8	81 x 101	4.0 x 1.5	4.0 x 1.5
			0.125	.125 x .312

Warning: In textile printing applications, follow only the machine manufacturer's instructions. In the case of extreme rectangular dimensions, consult the frame manufacturer for information.

2.4 Pre-treatment of frames

Screen printing frames should not have any sharp edges or pointed corners, since these can damage the mesh, which might tear when tightly stretched.

Sandblasted frames

Screen printing frames that have been sandblasted must be thoroughly degreased with a solvent (acetone) immediately prior to use. Greasy cleaning agents must not be used. After degreasing, frames that will be used with fine mesh (UV mesh and others with mesh counts of 255 or more) should be primed using the same adhesive that will later be used for gluing.

Metal frames that have not been sandblasted

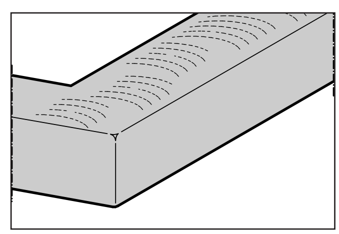
Metal frames with a smooth surface must be roughened prior to use.

Roughening

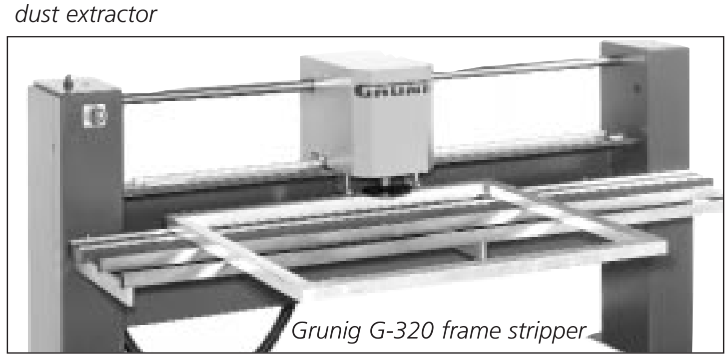
The recommended way to roughen adhesive surfaces, as well as remove stray glue from used frames, is to use a rotary grinder with an abrasive paper or fiber disc fitted to a rubber backing. The discs themselves should be around a 24 or 36 grit.

When working on the frame, it is essential to keep the frame surface truly flat and level, otherwise there could be contact and gluing problems later.

Rotary grinder with integrated dust extractor

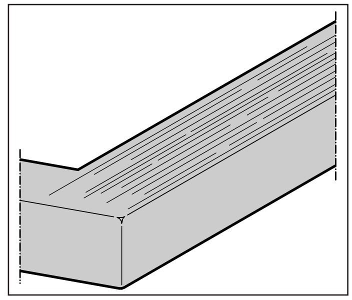


Frame surface after grinding



Grunig G-320 frame stripper

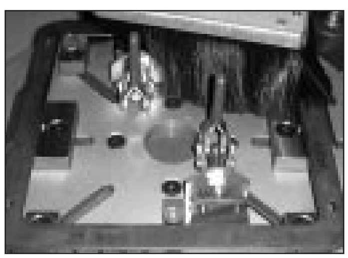
Belt sander, no. 24–36 grit. This technique gives a flatter frame.



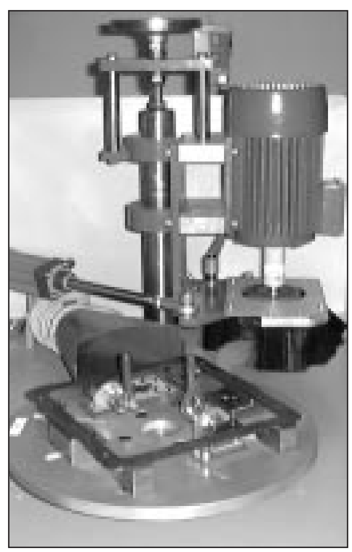
Frame surface after belt sanding. Because the grooves run parallel to the frame, solvents cannot penetrate between the frame and the mesh.

Ensure that all edges and corners have been de-burred.

Shortly before gluing, frames must be thoroughly degreased with a solvent (acetone). Greasy cleaning agents must not be used. After degreasing, frames that will be used with fine mesh (UV mesh and others with a mesh count of 255 or more) should be primed using the same adhesive that will later be used for gluing.

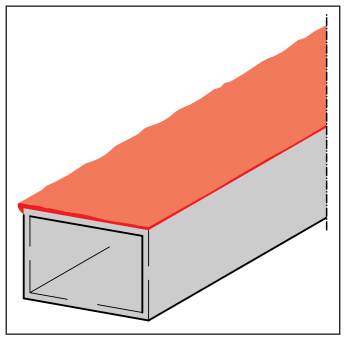


Sefar America SBM-400 CD frame stripper.

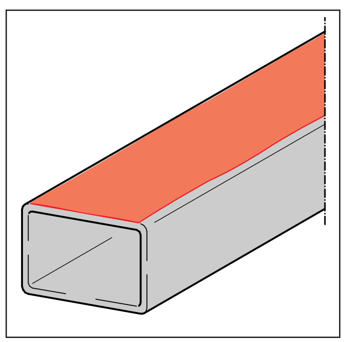


Cleaning used frames

Frames that have been used previously must be stripped of leftover mesh, ink and glue. The edges must be rounded, to avoid the risk of tearing the mesh. Old glue may be left on the frame surfaces, providing it is even (no holes or bumps) and the layer is not too thick.



Poor frame edge must be rounded-off



Frame after rounding-off the glue edges

Frames prepared in this way are now ready for gluing.

3. Stretching

Stretching systems

There are three basic approaches to stretching mesh, offering various degrees of precision.

– Hand stretching
– Mechanical stretching
– Pneumatic stretching

3.1 Hand stretching

The traditional method of stretching mesh on wooden frames by hand (aided by stretching grippers and staples) is still used by some screen printers.

It is essential that the mesh is also glued to the frame.

This technique does not give uniform, tightly stretched mesh. Warning: staples tend to tear the mesh.

Hand stretching

2 Mechanical stretching

A mechanical stretching apparatus produces tensioning forces in the warp and weft directions. Depending on the equipment dimensions, several frames can be stretched at once. Also angled positioning of frames is possible. The ability to stretch several frames at once increases productivity. However, mechanical apparatus is unable to pre-stress the frames. This can be achieved using separate equipment.

Mechanical stretching apparatus may be classified into two groups:

– Self-tensioning frames
– Spindle tensioning machines

f-tensioning frames

Roller frame

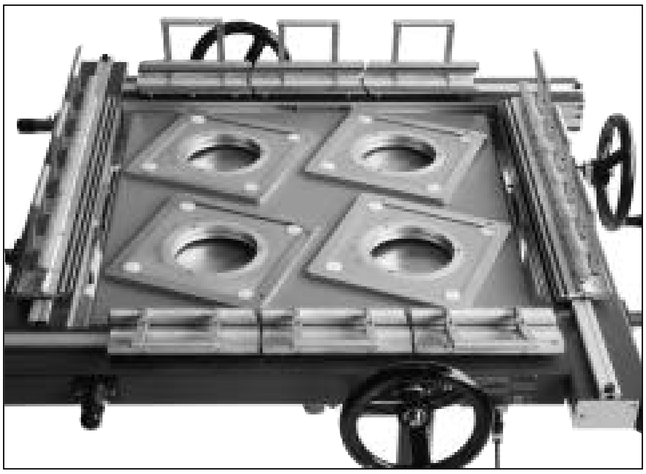
Mesh is clamped in the frame. Stretching is done by rotating or adjusting the frame sides.

Self-tensioning frames have the advantage that the mesh does not need to be glued to the frame.

Caution: Excessive mesh tension with improper mesh loading will increuse the risk of tearing at the corners.

Spindle tensioning machines

Spindle tensioning is another mechanical approach. The machine consists of a sub-frame supporting four guide-rails, which in turn carry pin rails or carriage clamps that grip the mesh. The grippers are moved by means of a threaded shaft, which is turned either by a hand-wheel, a ratchet, a torque wrench, or an electric motor. Tensioning is achieved by increasing the distance from the guide rails.



Grunig G-210 stretching machine

During the stretching process, the screen printing frame rests on a height-adjustable holder, to avoid contact with the mesh. The frame is raised into the mesh during gluing.

When gluing at an angle, the printing frame is set on the holder at the desired angle, while the mesh is stretched at right angles in the normal way.

etching machines with pin rails

In this type of machine, the mesh is hung over rigid pin rails attached to the stretching battens.

Pin rails are dangerous, particularly with fine-mesh counts. These require particularly careful handling to reduce the risk of tearing.

In stretching machines with rigid, laterally fixed stretching battens, the corners of the mesh must be handled with special care to avoid over-stretching. Over-strained corners often cause torn mesh during and after stretching.

To reduce the possibility of this happening, the corners must be free and then gradually pinned, so they have the correct tension after stretching is complete.

Tensioning machines with single clamps

This type of machine replaces pin rails with movable clamps. They run on ball bearings and can follow the mesh as it stretches. This accommodates length changes during stretching.

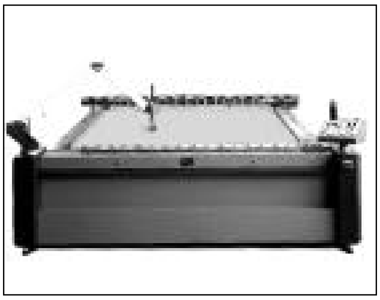
Grunig G - 201 Clamp

Grunig G - 210 Stretching machine

ni-automatic mechanical stretching machines

Semi-automatic mechanical stretching machines provide continuously variable tensioning by mechanical means alone. Force is applied by means of an electromechanical drive mechanism that pulls the stock clamps outwards on both guide-rails at once, or each one in turn.

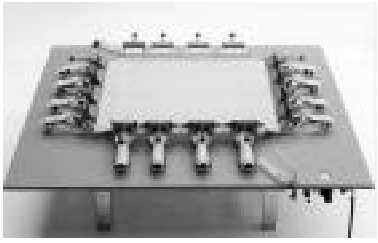
These machines are suited to large-size frames, or for covering several smaller frames at once.



Grunig G - 280 Semi - automatic mechanical stretching machine

3 Pneumatic stretching

Pneumatic stretching machines consist of many individual stretching clamps, linked together and acting independently. The clamps are operated by compressed air, and the number of clamps used depends on the frame size.



Sefar - 3 Tabletop pneumatic stretching system.

The clamps are constructed in such a way that they prop themselves against the printing frame during stretching. The tension applied to the mesh also comes to bear on the frame edges. The frame is thus automatically given the necessary pre-bow to avoid excessive loss of mesh tension after gluing.

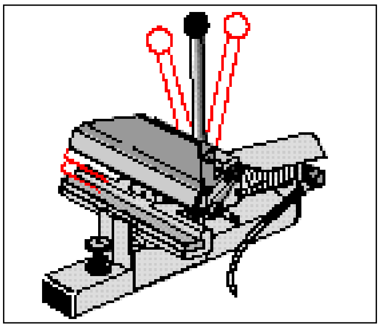
Since the clamps are held under steady pre-set air pressure, mesh tension remains constant right up to the time of gluing.

SEFAR 3

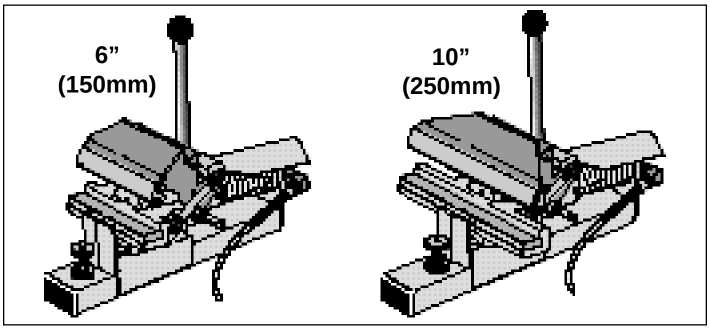
The **SEFAR 3** stretching clamp is pneumatically operated, with a manual closure.

The mesh is clamped between two dissimilar rubber profiles (round/flat) to prevent slippage. The jaw clamping force may be set using a torque wrench.

The clamp is designed to be equally suitable for fine or coarse meshes, and low to extremely high tensions.



SEFAR 3 stretching clamps are available in jaw widths of 6" (150 mm.) and 10" (250 mm.) Both types can be used simultaneously, one beside the other, since the pulling strength of both clamps is proportionately the same. Therefore, the clamps can be arranged to suit any frame size.

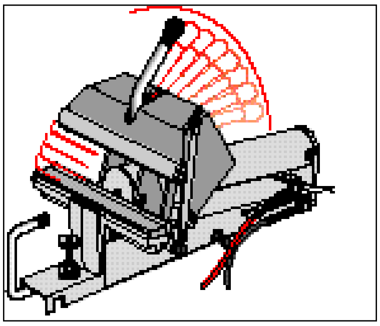


Sefar 3 clamps with 6”(150 mm) and 10”(250 mm) jaw widths

Pneumatic unit with distributor mounted on table

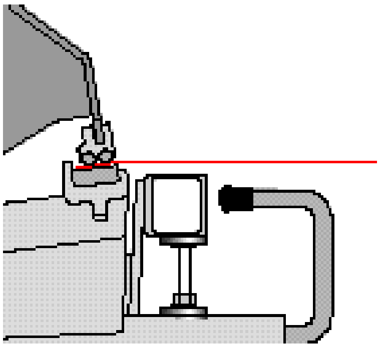
:AR 4

SEFAR 4 stretching clamps feature a progressive jaw action that applies a steadily increasing clamping force. The force grows in proportion to the mesh tension, preventing slippage. The combination of constantly adjusted clamping force and plastic jaw inserts allows higher tensions than can be achieved with conventional clamping systems.



SEFAR 4 clamps are elevated by a short-throw cylinder during the stretching process. This avoids undesired rubbing of the mesh against the frame.

The clamps are propped against the frame, flexing it in proportion to the applied tension. This ensures consistent tension even after the mesh is glued to the frame.



SEFAR 4 stretching clamps feature automatic closing and locking, as well as retracting and opening automatically after stretching is complete. The progressive clamping force means that the clamps may easily be opened and closed by hand.

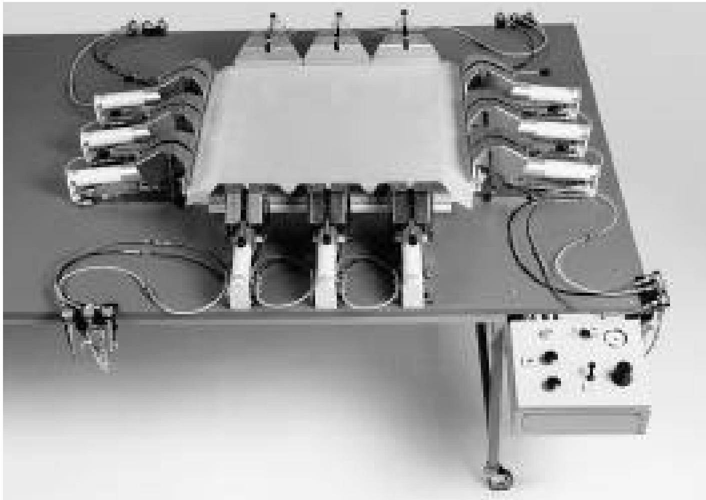
SEFAR 4 stretching clamps are available in jaw widths of 6” (150 mm.) and 10” (250 mm.) Both types can be used simultaneously, one beside the other. Therefore, the clamps can be arranged to suit any frame size.

Pneumatic circuits

There are two ways to arrange the air supply for pneumatic stretching machines: the single-circuit system, and the dual-circuit system. They provide complementary alternatives for optimum, even tensioning of the mesh over any frame size.

gle-circuit system

The single-circuit system is recommended for frames with sides under approximately. 60” long.

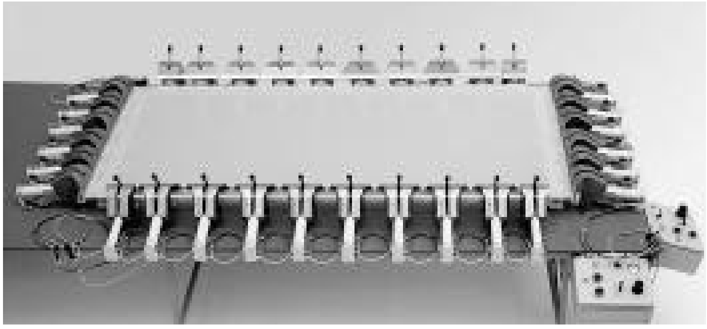


With the single-circuit system, clamp positioning must correspond with the inside edge of the frame.

The single-circuit system uses a single control box, with two air outlets. One is connected directly to the first clamp, the other to the clamp diagonally opposite, in order to supply compressed air to both sets of clamps. They are also linked by a pneumatic coupling in the other diagonal corner.

Dual-circuit system

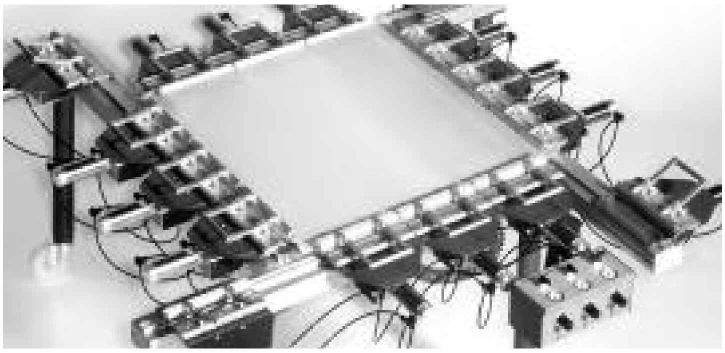
Dual-circuit systems allow for optimal tensioning conditions. With a dual circuit system, the warp and weft mesh directions may be independently adjusted to achieve even tensions over the entire surface of the frame.



Dual-circuit systems provide even tensions for large format rectangular frames (60 inches and larger).The clamps on both short sides of the frame must be positioned so that the clamp ends overhang by one frame section width. The clamps on each of the long sides must be spaced approximately 1.5-2.5 inches away from the outside edge of the frame.

The dual-circuit system uses two independent control boxes. One supplies the short side (warp), the other supplies the long side (weft). This allows pre-tensioning the warp to half its final value, before clamping the weft and likewise pre-tensioning to half the final value. Both circuits can now be adjusted in tandem to attain the final desired tension. This technique improves the evenness of the mesh tension.

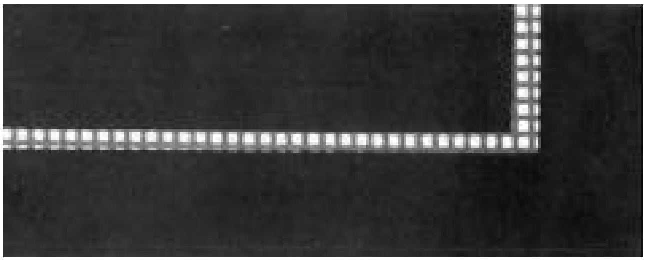
3.4



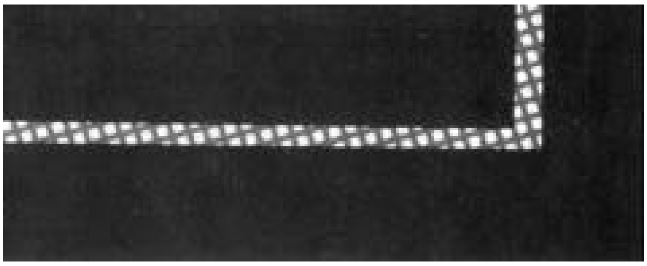
The Grunig G-215 pneumatic stretching unit utilizes a dual-circuit air system

Stretching at an angle

Lines running parallel to the screen frame can be accurately printed when the mesh is stretched at an angle. It is important that the mesh and the lines to be printed are not parallel to each other.



Mesh stretched parallel to the frame.



Mesh stretched at a 15° angle.

etching methods

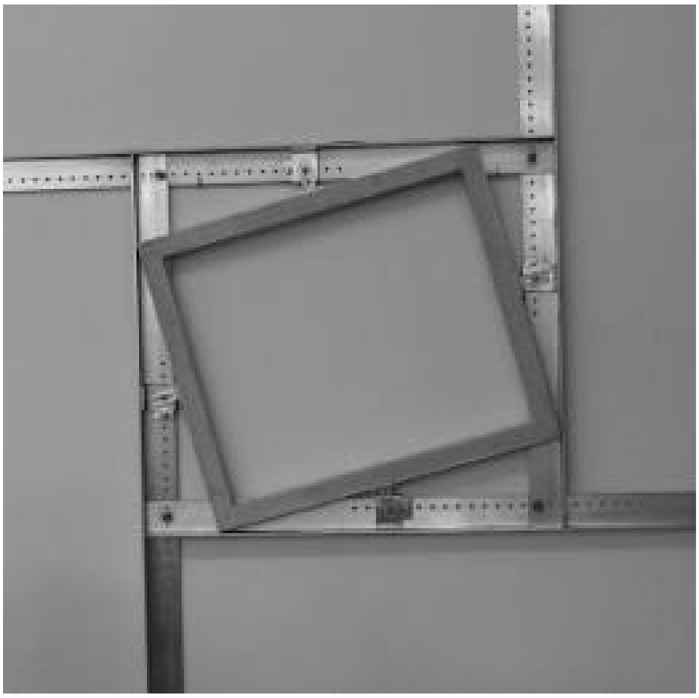
With mechanical stretching, the printing frame is placed in the stretching machine at the desired angle.

With pneumatic stretching, two techniques may be used.

The mesh is cut at the desired angle and placed straight into the stretching clamps. Stretching difficulties arise when the mesh angle is greater than 15°, because the mesh is not stretched in the direction of the threads. This method is only recommended when the use of a master frame is not practical

There are fewer problems when using a master frame. This is placed into the stretching apparatus, and the screen frame can now be positioned at the desired angle. The mesh is stretched straight in the direction of the threads. There is a loss of tension if the frames are too weak, because the clamps are propped against the support or master frame, and not against the stencil frame.

Aluminium profiles should be at least 3.1/1.6/.24 inches for lengths up to approximately 6.5 feet. In order to quickly adjust the profile to various formats, bore holes at 1.25 " intervals along the profile.



4 adjustable prop profiles transfer the tensioning force to the tensioning frame. This reduces the loss in mesh tension.

3.5 Multiple stretching

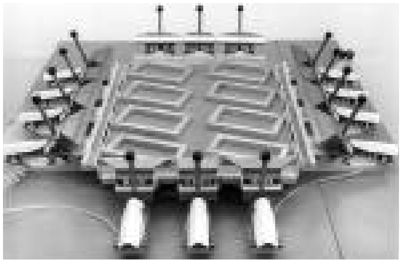
Several frames may be tensioned at once, using a master frame and one stretching machine.

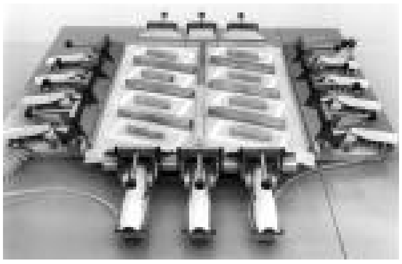
Master frames are especially useful for covering small stencil frames. The master frame is tensioned, the small stencil frames are placed on a foam rubber underlay, and the master frame is placed over them. Small weights can be positioned on top, to improve contact between the mesh and the frame.

Covering several small frames with a master frame

A wooden or metal plate can be placed in the stretching apparatus. Several identical or different sized frames can be positioned straight, or at an angle.

It is essential to position weights on the mesh between the individual frames, to ensure optimal contact with all the frame edges.





3.6 Correct stretching

After stretching, the screen printing mesh is mounted onto the frame. The permissible tension depends on the tearing strength of the particular mesh. The resistance to stretching of a particular mesh is an important factor in ensuring correct registration, and in determining the proper distance between the screen and the substrate.

Tension is measured in Newtons per cm (1 N = 0.102 kp) with mechanical or electronic equipment placed on the mesh.

See also the section "Checking mesh tension".

Optimum tensioning force varies with different mesh types.

The optimum stretching force to be applied in psi of selvedge depends, as previously mentioned, on the tearing strength and stretching resistance of the particular mesh.

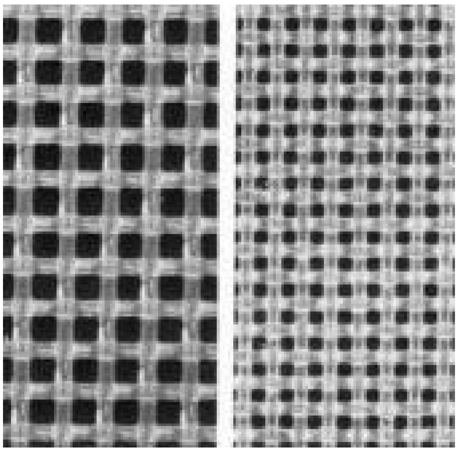
The tearing strength and stretching resistance of modern synthetic yarns depends on the material and manufacturing process used.

Polyester and polyamide (nylon) have very similar tearing strengths, but considerably different stretching characteristics. Polyester is more stretch-resistant than polyamide, and high-viscosity polyester is more stretch-resistant than standard polyester.

Apart from this difference between the tearing strength and the stretching resistance of different yarn materials, for one and the same material it may be stated, in principle, that both these values will be roughly proportional to the cross-sectional area of the yarn. The cross-sectional area of a round yarn thread is obtained by the familiar expression $(\pi)r^2$, (i.e. 3.14 x square of the radius or .785 x diameter squared). This means that a round thread A that has double the diameter of another thread B of the same yarn material will be about four times as strong in tearing and stretching. With increasing thread diameter, therefore, the strength values increase according to their squares.

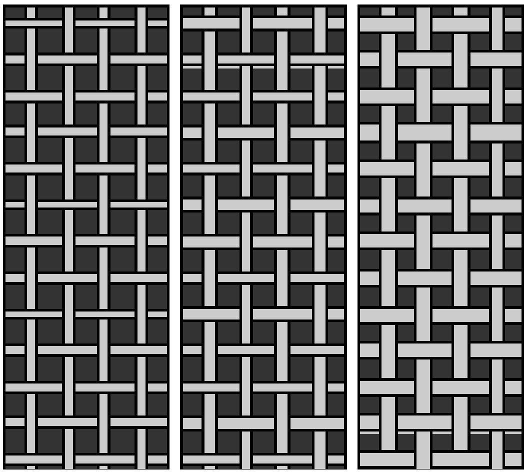
Stencil meshes are made in different degrees of fineness (counts). The count represents the number of threads per linear inch.

In general, the higher the number, the finer the threads. Coarse mesh with relatively thick threads can be tensioned to higher tension than fine mesh, even though they stretch less.



195-48 PW *305-40 PW*

Moreover, in the same weave counts (same number of threads per linear inch), mesh can be woven from combinations of thinner and thicker yarns.



305-31 PW *305-34 PW* *305-40 PW*

Considering the different mesh grades with the same number, i.e. the same mesh count, it is obvious that the grade with the thicker yarn is stronger than the grades with the thinner yarns. This should be taken into account when stretching on printing frames.

Mesh count with threads of differing thickness used to be specified as:

SL	=	thinnest thread
S	=	thin thread
M	=	medium thread
T	=	thick thread
HD	=	thickest thread

Now, these symbolic terms have been replaced by the nominal thread diameter. Nominal thread diameter refers to the diameter of the unwoven fiber.

Mesh count	Thread diameter	Former identification
305	31	S
305	34	T
305	40	HD

The complete mesh identification is comprised of:

Mesh type + mesh count + thread diameter + color + weave type.

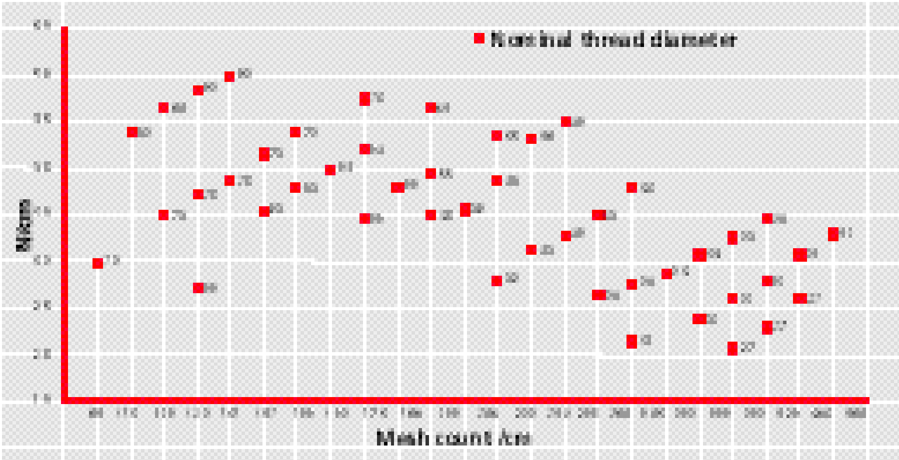
As yet, there are no standardized symbols for special treatments; mesh manufacturers use their own abbreviations.

Example: Pecap LE 305-34Y PW

3.7 Recommended tensions

The recommended tensions refer to target values for the mesh in the tensioning apparatus, before it is attached to the printing frame. These are reliably attainable using correct tensioning methods and well-maintained tension measuring equipment. Higher than recommended tensions increase the risk of tearing during handling and printing. Lower tensions may be necessary for specific applications (hand printing, printing solid objects).

Maximum tensions for Pecap LE mesh:



The tensions listed in the table refer to measurements made using the SEFAR Newtontester or TETKOMAT.

Preconditions:

– tensioning system with pre-stressed frame
– SEFAR-3/4 stretching clamps or other devices capable of providing uniform tension
– slip-proof mesh clamping system
– stable frame

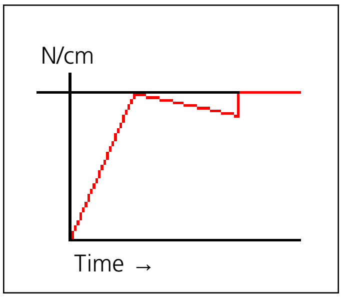
Applicability

The specified tensions are valid for frame edge lengths up to approx. 40 inches.
For larger sizes, the specified tensions should be reduced by 15–20% for edge lengths up to approximately 78 inches, and 20–25% for edge lengths up to approx. 118 inches

Standard tensioning procedures

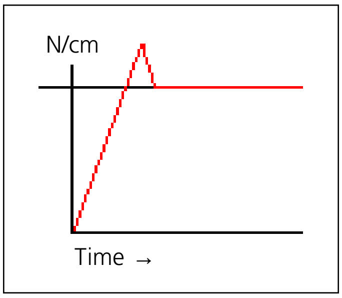
The mesh can be brought to the desired tension within 1 to 3 minutes. Before fastening the mesh to the frame, wait 10 minutes and again increase the tension to its final value. Repeating this procedure several times will reduce future loss of tension.

With modern pneumatic equipment or SEFAR clamps, tensioning time may be reduced to an absolute minimum.
(1 minute)



Rapid tensioning procedure

Within 1 to 3 minutes, the mesh can be brought to a tension some 15% higher than desired, then attached to the printing frame without delay (no relaxation phase).



Loss of tension

When tensioning procedures are correctly followed, there is a loss of tension of 15–20% with standard mesh, and 10–12.5% with Pecap LE. These values do not take the printing frame characteristics into account. Loss of tension can be reduced by longer relaxation phases.

›sible causes for loss of tension

The following points should be investigated if loss of tension is problematic:

- weak frame sections
- mesh incorrectly inserted in the stretching clamps
- stretching clamps pull unevenly: one side of the frame is laying too high
- large temperature changes
- insufficient waiting time before gluing

Extreme climatic or mechanical influences can also affect the mesh tension.

Because the mesh must have a certain degree of elasticity during the printing process, undue demands should not be made on the tension. Differences of 1–2 N/cm are permissible. Multi-color graphics printing experience has shown that good registration is achieved at mesh tensions above 12 N/cm. It is important that all the frames used are tensioned similarly.

asuring tension

There is a relationship between the applied stretching force and the resulting elongation of the mesh. The relationship (cause and effect) is, however, not constant for different types of stretching equipment and mesh.

We recommend using a commercial measuring instrument, e.g. the SEFAR Newtontester or TETKOMAT, for determining mesh tension.

If specialized measuring equipment is unavailable, mesh tension can be roughly checked by monitoring elongation during tensioning.

Elongation in percent at 15–20 N/cm:

Mesh count	Polyester mesh	Polyamide mesh
25 - 54	1 - 1.5 %	2 - 3 %
54 - 130	1.5 - 2 %	3 - 4 %
130 - 255	2 - 2.5 %	4 - 5 %
255 - 480	2.5 - 3 %	5 - 6 %

3.8 Sefar tension measuring instruments

Newtontester

Screen printing quality largely depends on perfectly controlled screen tension. The Sefar Newtontester instantly measures the screen tension in Newton/cm and displays it on a large, highly legible dial. Sturdy and precise construction guarantees consistent, reliable and exact screen tension reading. Tension values from 5–60 Newton/cm can be checked.

Instructions for use

Calibration

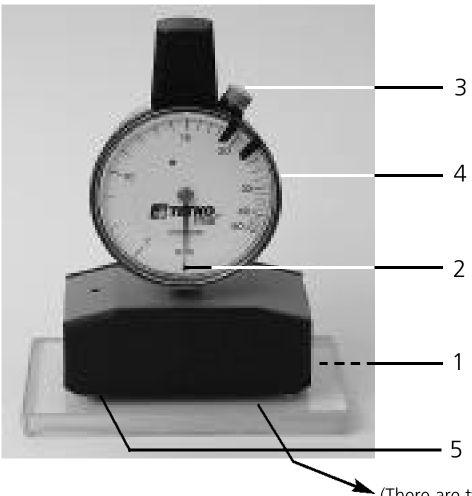
The accuracy of measurement and the indicator dial should be checked periodically. The Sefar Newtontester is placed on the glass plate delivered with the instrument for this purpose:

– The needle of the dial must be precisely in the 12 o'clock position. Any deviation can be corrected by turning the hexagonal set screw at the bottom of the tester. The appropriate Allen wrench is packed with the instrument.
– The calibration point on the dial should be made to exactly coincide with the indicator needle by turning the outside ring of the dial.

The Sefar-Newtontester is now ready for use.

Measuring

Place the Sefar-Newtontester onto the mesh and read the tension.



TETKOMAT characteristics

The TETKOMAT is suitable for all screen printing mesh. It is a purely mechanical instrument, needing no battery or other electrical supply.

The Tetkomat allows reliable and simple checking of mesh tension in warp and weft directions at any time. This makes it possible to produce uniformly tensioned, reproducible stencil sets.

Measuring mesh tension

Before starting to use the Tetkomat, check that the display is correct, i.e. the indicator needle must rest exactly over the scale calibration point as the instrument sits on the glass calibration plates (see Checks and Adjustments below).

To measure mesh tension, place the instrument on the tensioned mesh so that the long edge of measuring head (1) is parallel to the thread direction. If the measuring head is aligned with the warp mesh, the instrument displays the warp tension. If it is aligned with the weft threads (across the mesh), it displays the weft tension. This allows the tension to be balanced in both directions.

Checks and adjustments

To avoid measurement errors, the instrument should be calibrated regularly, checked, and adjusted if necessary.

- Clean the measuring bar and the supplied glass plate of any dirt.
- Place the instrument on the glass plate.
- The needle should rest exactly over the scale calibration mark (2).
- If the needle shows a deviation, loosen the scale set screw (3).
- Turn the outside ring of the dial (4) so that the needle aligns with the calibration mark (2).
- Remove and replace the instrument on the glass plate several times, to verify reproducibility. (The instrument should be cleaned if reproducibility is poor.)
- Tighten the scale set screw (3); the instrument is now ready for use.

Important: Minimum distance from frame: 2.5 inches
To avoid erroneous readings, the instrument's contact rollers (5) must lie parallel to the direction of the threads. Follow the mesh tension recommendations in the technical datasheets published by SEFAR AMERICA INC.

Loss of tension

A newly stretched screen loses approx. 10–20% of its tension within the first 24 hours, depending on the type of tensioning device used, the original mesh tension, the frame stability, and the waiting time before gluing. For printing jobs with accurate register, therefore, it is recommended to let the screens rest for 24 hours before coating. When stretching frames, please take into account this loss of tension.

We recommend working with N/cm measuring instruments at all times.

For multi-color work, all screens should have the same tension. Verification of screen tension with a N/cm measuring instrument is therefore especially important.

Practical experience has shown that variations in screen tension of 1–2 N/cm on the same or different screens does not have any noticeable effect on screen printing precision.

During long print runs, or after several screen reclaimings, the loss of tension can amount to several N/cm.

Caution: Unequal warp and weft tension can result in the following:

- uncontrollable registration
- deteriorating surface roughness of the ink volume
- higher ink volume (depending on the squeegee direction)
- increased mechanical abrasion of the mesh and squeegee
- moire’

4. Gluing

Applying two-component glue through the mesh is the technique most used at present for adhering mesh to printing frames.

One-component glue, UV or cyanoacrylate adhesives are other alternatives.

The choice of glue depends largely on the solvents used by the printing process.

4.1 Preparation

Screen printing frames must be thoroughly cleaned and degreased prior to gluing. There must be no traces of dust, grease or oxidation.

The tools used are:

- a plastic applicator or brush with hard bristles, optional brush-holder for storage
- degreasing agent
- adhesive tape
- felt-tip marker
- a knife

Cleaning and degreasing the printing frame

First, the side of the frame to be glued must be cleaned, and ink and adhesive residue removed. If the old glue coating is non-porous and flat, it may be left on the frame.

Sharp edges and corners must be rounded off.

It is always advisable to roughen the adhesive surface of metal, in particular aluminum, using a coarse emery wheel or emery disc. Sand-blasting the surface to be glued is also a good method.

Printing frames should only be roughened or sand-blasted on the side to be glued, otherwise it is more difficult to remove ink residue.

Metal frames should be thoroughly degreased shortly before gluing, using a suitable solvent (cellulose thinner, acetone, refined petrol, or alcohol). Prepared frames should be glued right away, to avoid the risk of recontamination.

When gluing mesh with mesh counts of 255 and up, it is beneficial to pre-coat the frame with the same glue that will be used later. This improves adhesion.

4.2 Marking stretched frames

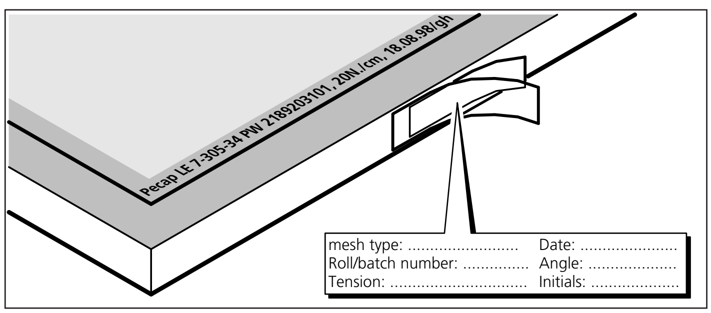
Before gluing, it is advisable to mark the tensioned mesh along the frame edge, using a felt tip marker. The following information should be recorded:

– mesh brand
– mesh count, including thread diameter and weave
– roll/batch number
– tension in N/cm
– date
– operator's initials

Example:
Pecap LE , 305-34 PW, 2189203101, 20N/cm, 8APR98/GH

Next, adhesive tape is applied inside of the marked mesh, approximately 0.5 to 1inch from the frame. This helps to give a cleaner glue boundary, and protects the transitional area between the frame and the marked mesh.

To make the frame easier to find in a storage rack, a sticker with the same information should be applied to the outer edge of the frame. The sticker can be made of self-adhesive plastic film or paper, and written with permanent marker. A piece of polyester film glued over the label protects against solvents.



Glued and marked mesh

4.3 Adhesives

There are various adhesive systems, falling into the following categories:

– two-component adhesives
– UV adhesives
– cyanoacrylate adhesives

Two-component adhesives

Two-component adhesive is a catalytic mixture consisting of the adhesive itself, plus hardener. This type of adhesive has generally good resistance to solvents, although the adhesive should be tested with the solvent used for ink removal.

Adhesive and hardener must be mixed before use, in the proportions specified by the manufacturer. It is important to observe the correct ratio, to avoid impaired adhesion and hardening.

Two-component adhesives harden in two phases. The solvent evaporates first, then the chemical hardening process begins.

The initial drying (evaporation) time depends on the fineness of the mesh, tension, thickness of the glue coat, room temperature and relative air humidity. With so many variables, it is difficult to recommend precise drying times. It is therefore advisable to follow the manufacturer’s instructions before removing the frame from the stretcher.

As a general rule, the higher the tension and the lower the mesh count, the longer the drying time required.

It should also be noted that two-component adhesives only remain workable over a limited period, since the reaction between the adhesive and the hardener begins in the pot. The delay between mixing and the onset of the chemical reaction is known as the pot life.

Liquid Staple is a two-component adhesive

UV adhesives

UV adhesives are one-component glues that cure (harden) through exposure to ultra-violet light from a special lamp. The hardening process is faster than with two-component adhesives.

UV adhesives are resistant to most solvents.

Cyanoacrylate adhesives

Cyanoacrylate (CA) adhesives are instant curing adhesives, when used in conjunction with an activator. A mist of adhesive is distributed onto the mesh and worked in the mesh over the surface of the frame profile. An activator is sprayed onto the adhesives, causing it to cure instantly. CA adhesives require minimal operator involvement and are available in multiple viscosities. Viscosity is determined by mesh count.

Frame Fast CA adhesives.

4.4 Gluing the mesh to the frame

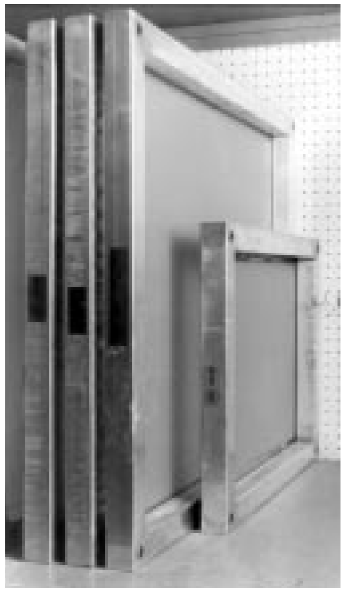
It is important to ensure intimate contact between the mesh and the frame during gluing. If there are problems, weights may be placed on the mesh to force it onto the frame surface.

It is important to ensure that the frame edges are thoroughly glued to the mesh, so there is no possibility of solvent penetrating and weakening the glue.

If the frame is not flat, it is impossible to establish good contact, and the mesh bond is correspondingly weaker. There is a risk of the mesh becoming detached later.

Gluing

4.5 Screen storage



Screen storage and transport

4.6 Stretching services

Efficient networks of SEFAR trade supply houses guarantee prompt and reliable delivery of perfectly stretched screen printing frames. You can be certain that the mesh has been stretched using state-of-the-art equipment, and the tension checked with appropriate measuring instruments.

It should be evident that prefabricated, ready-to-use frames are the safest and best prerequisite for making perfect stencils. Successful printing largely depends on this.

A stretching service saves you warehousing costs for various mesh counts and widths, as well as the investment in a stretching machine. Put your premises and expensive labor to better use!

5. Film positive manufacturing

In screen printing, stencil preparation requires a positive transparency of the artwork to be reproduced.

It is important that the film positives are right reading, with the emulsion side up. Flim positives can be made manually, photographically, or digitally.

5.1 Manually made film positives

- Draw with opaque ink on transparent polyester foil. For artistic prints, a wax pencil can also be used. It is preferable to use one-sided matt polyester foil.
- Cut-film process. The film positive is prepared on a masking film, consisting of a polyester backing and an emulsion coating. Cutting may be done using a special knife, or a computer-controlled plotter.

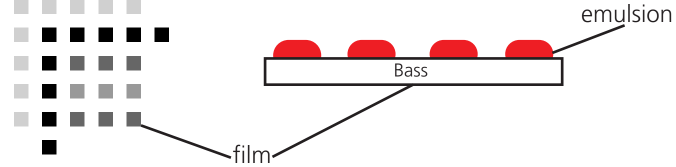
Masking films are available in orange and red. Both types are suitable for screen printing, but for photographic reproduction only red masking films should be used.

5.2 Photographically made film positives

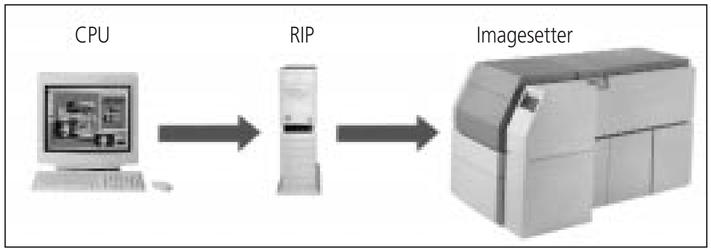
At present, the conventional technique generally used to make screen printing film positives requires a positive, reading right film. In this context, right reading means that the artwork must be able to read correctly when viewing from emulsion side of the film. This is the opposite to films intended for offset printing.

If film positives are made externally, it is essential to instruct the film trade shop to expose the artwork right reading on the emulsion side of the film.

This is important, during exposure, because it allows the emulsion side of the film to rest directly on the stencil emulsion. If reversed films (wrong reading) are used, the film polyester base becomes interposed between the emulsion and the film layer. This causes undercutting, producing stencils that lack sharpness and detail.

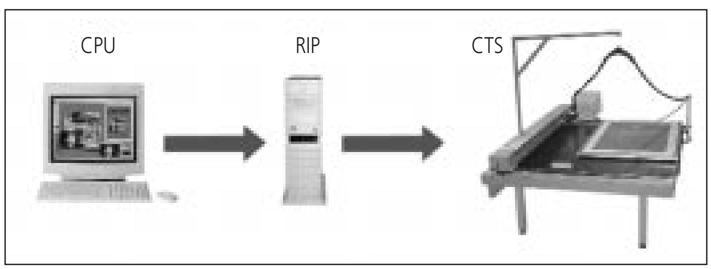


Films are currently produced on laser imagesetters. Computer data is converted to screens and lines by a PostScript RIP (Raster Image Processor), and translated into the imagesetter's machine language. The result is then output to film.

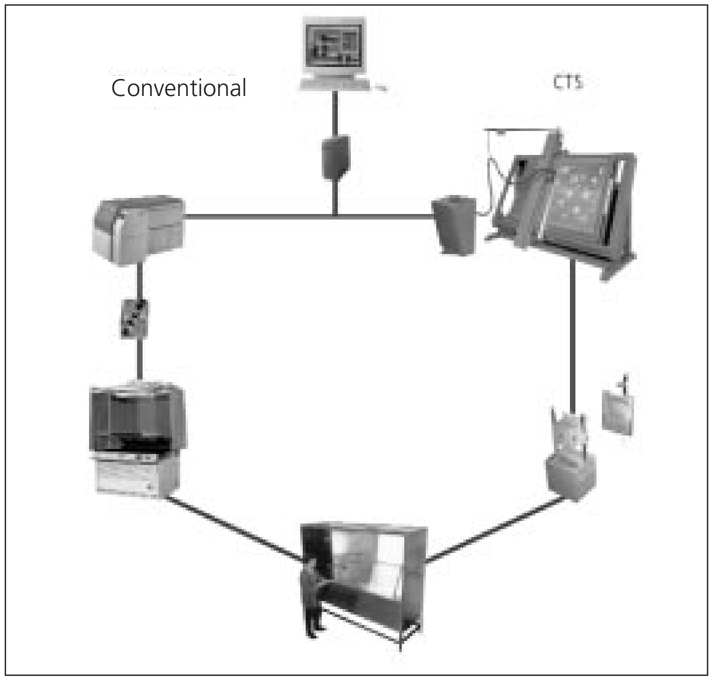


5.3 CTS (Computer to Screen)

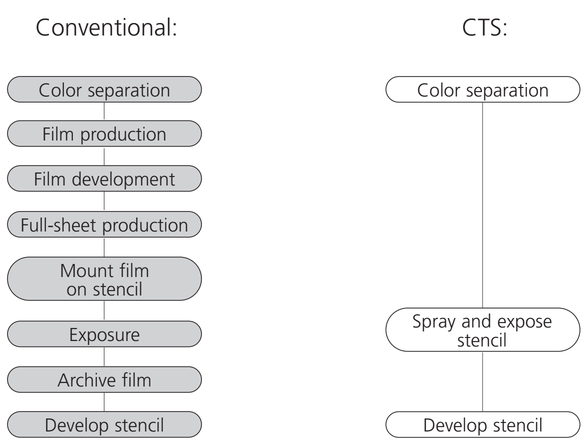
CTS is a newer process for making positives images. Just like film production, computer data is converted by a RIP and output on an inkjet plotter. However, no actual film is involved: instead, the plotter sprays UV-opaque ink or wax directly onto the coated mesh. The mesh is then exposed and rinsed in the same way as stencils made from films. This technique does not require vacuum retention during exposure, because the ink or wax is deposited directly on the emulsion surface.



This technique has the advantage of eliminating expensive films. For producing screen printing stencils, inkjet technology has proved a clear winner over laser techniques (same principle as CTS). Only a few laser machines are in use world-wide; they are much slower and require special emulsions and mesh types.



Conventional film-based production vs. CTS



5.4 Tips for external production of film positives

If pre-press facilities are not available in-house, it is necessary to work closely with an expert partner. The best choice is a film trade shop with an established track record in making screen printing film positives.

Most repro houses are oriented towards offset printing. It is absolutely crucial to discuss the specific job requirements beforehand.

1. Positive films must be made right reading with high density ($D_{min} \geq 3.5$) to UV-A illumination.
2. Film positives must not be made using PostScript round dots. While eminently suitable for offset printing, these are a big problem in screen printing. This is because dots for 50% tones are square, and frequently cause moiré.
3. Most film trade shops offer a wide variety of raster techniques (Eliptical, linked, etc.). Trials with various dot shapes are essential.
4. It is a good idea to make a test film with a variety of raster dot shapes with different screen rulings (lpi). Proof prints from test stencils made from various film materials on different mesh counts provide a basis for establishing subsequent standardized practice.
5. Multi-color halftone prints present a further dimension. Having established the optimum halftone dot shape, the best halftone angle must then be found. A proof print with various four-color halftone angles is made; the print results then determine which standard raster angle to use.

Once all these parameters have been established, there should be fewer moiré problems in production runs. Informing customers of the optimum parameters beforehand can also save much trouble and expense.

To reiterate, here is a summary of the parameters:

- correct side (i.e. right reading), with proper Dmin and Dmax densities
- optimum halftone dot shape
- optimum halftone angle
- optimum halftone ruling

6. Stencils

6.1 Pre-treatment of screen printing mesh

Degreasing

Special finishing methods means that SEFAR screen printing mesh is fundamentally very clean. Irrespective of this, all mesh, whether new or old, must be degreased shortly before use. Mesh can be contaminated by handling, or airborne dust.

Degreasing is done with the normal screen printing degreasing products available from dealers. Household detergents must not be used. They often contain other chemical additives, e.g. lanolin for skin protection, which can seriously affect the adhesion of photographic emulsions.

After degreasing, the mesh should not be touched again. Photographic emulsions must be applied immediately after degreasing the mesh. If screens are allowed to lie around, the mesh may again attract grease or dust.

Degrease by spreading a modest quantity of degreasing agent over the wet mesh, using a soft brush. Leave to stand for a few minutes, then rinse thoroughly using a high-pressure water jet.

6.2 Mechanical stencils

The hand-cut stencil

This type of stencil has the advantage of producing perfectly sharp edges. It is mostly used for lettering and large solid objects. The stencils for the individual colors are easily cut using a special cutting knife, e.g. a swivel knife.

Suitable cutting tools and masking films can be obtained through your screen printing dealer.

Plotter techniques have created a resurgence in hand-cut stencils.

Water soluble hand-cut film

This kind of hand-cut film has the following advantages:

- film adheres to the mesh by water surface-tension
- suitable for all solvent-based inks
- easy removal with hot water

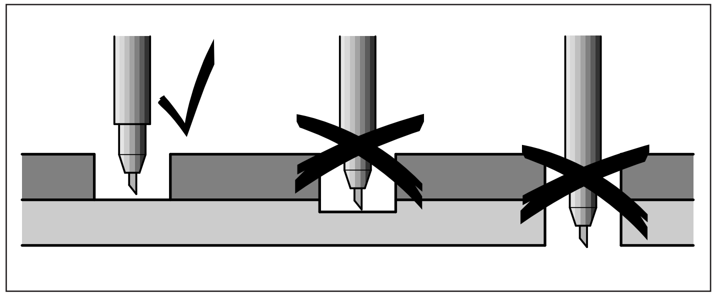
Cellulose hand-cut film

The following points should be observed with this film:

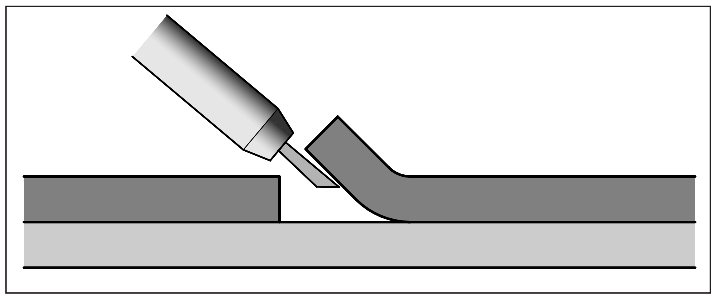
- The mesh must be prepared and degreased as with a photo stencil.
- For perfect adhesion, the solvents recommended by the film manufacturer must be used.
- Hand-cut films bonded with solvents resist only water-based inks.
- Can be removed using solvents.

Potential Problem

- Hand perspiration, hand cream, or dirt on the film side can create bonding difficulties.
- When cutting, the hand should rest on a protective sheet of paper to avoid grease-stains.
- Insufficient pre-treatment and poor adhesion degreasing of the mesh (see the section on pre-treatment).
- Creased film.
- Poor contact may result while bonding.
- Excess liquid while bonding results in swollen edges.
- Drying at excessive temperature.
- Using an unsuitable instrument to lift off the film.



Cutting



Lifting

6.3 Photomechanical stencils

	A **Direct stencil** with emulsion	**B** **Direct stencil** with film and emulsion	**C** **Direct stencil** with film and water (capillary film)	**D** **Indirect stencil**
– Mesh cross-section – Emulsion – Film				
Mechanical resistance	very good	very good	good	poor
Solvent resistance	good	good	good	good
Contour sharpness	good – very good	very good	very good	very good
Average press run	50 000-75 000	20 000-50 000	10 000-30 000	2000-5000
Time and labor	high	high	low	medium
Applications	Printing of flat and shaped objects	Printing of flat and shaped objects	Printing of flat and certain shaped objects	Flat print
Reclaiming	difficult	difficult	easy	easy

6.4 Direct stencils with emulsion

General procedure

Degreasing	Before making any stencil, the mesh should be degreased with a suitable degreasing agent. Do not use household detergents.
Drying	Remove all water by suction. Dry thoroughly at room temperature or in screen drying cabinet
Coating	Uniform coating with photo emulsion (diazo, photopolymer or dual cure), wet-on-wet. Use a suitable coating trough.
Drying	Dry the stencil in a horizontal position, print side down. Maximum temperature 105ºF.
Additional coatings	Apply additional coatings on the print side, to smooth out unevenness.
Drying	Same drying procedure as after the first coating.
Exposure	Use a suitable light source, e.g. a metal halide lamp. Determine the correct exposure time using step exposures and a test film.
Developing	Develop with a moderate water-jet. Observe manufacturer's temperature instructions. After development, rinse out the printing side thoroughly with a powerful water-jet.
Drying	Remaining moisture can be removed by gentle application of unprinted newspaper or window cleaning suede, or using specialized water suction equipment. Final drying in a drying chamber.
Retouching	Pinholes and film edges can be covered with screen filler.

6.5 Troubleshooting direct stencils with emulsion

Formation of fish-eyes after coating

- Insufficient degreasing of the mesh.
- Dust particles on screen mesh.
- Poorly mixed photo-initiator (diazo) and emulsion. (inhomogeneous coating)

Air inclusions during coating

- Coating too fast can trap air in the mesh openings. (Formation of bubbles leads to premature printing failure.)

Poorly bonded photo emulsion after exposure

- Emulsion insufficiently dried before exposure.
- Exposure time too short. Failure to compensate for a highly light-absorbent film positive.
- Intensity fall-off in the exposure lamp. (Measure the output using a light integrator.)
- Insufficiently sensitised emulsion. Incomplete dissolution of the diazo component in water. Some of the diazo sensitiser remains undissolved in the bottle.
- Caution at very high humidity. The coated screen may feel completely dry, but is only superficially dry due to the high air humidity. Allow for longer exposure times under these circumstances.
- After coating, leave coarse meshes to dry overnight at room temperature.

Undercutting (loss of detail)

- This can occur with white mesh. Use a dyed mesh. Compared to white mesh, dyed screen mesh require a 75–125% exposure increase.
- Use emulsion up film positive.
- Stencil is over exposed

Saw-tooth effect

- Poor coating.
- The coating on the print side is too thin. The coating bridges the mesh openings, but has sunk into the depressions in the mesh structure.
- Printing sharp outlines requires multiple wet-on-wet coatings. The greater part of the photo emulsion must be, in any case, on the print side.
- After drying, additional coatings can be applied to smooth out unevenness.

Halftone printing

- Halftone screen printing requires thinly coated mesh. Apply an additional coat to the print side.

Reclaiming difficulties

- Underexposed emulsion.
- Ink was not immediately washed off after printing.
- Insufficient cleaning after printing. Ink deposits cling to the mesh. After a certain time, the dried ink particles can no longer be completely removed.
- The stencil is still greasy from solvent. The reclaiming solution cannot dissolve the photo emulsion. Additional degreasing is needed before applying the reclaiming agent.
- Unsuitable reclaiming agent.

6.6 Stencils for water-based inks

Water-proof emulsions must be used with water-based inks, e.g. for direct printing on textiles or ceramic.

Carefully observe the manufacturer's instructions.

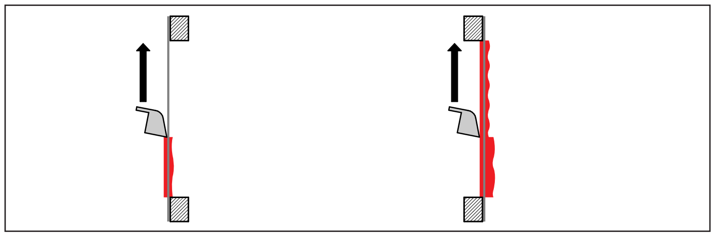
Sensitizers

DIAZO and/or PHOTOPOLYMERS are used as sensitizers in screen printing.

Important: For environmental reasons, DICHROMATE should no longer be used.

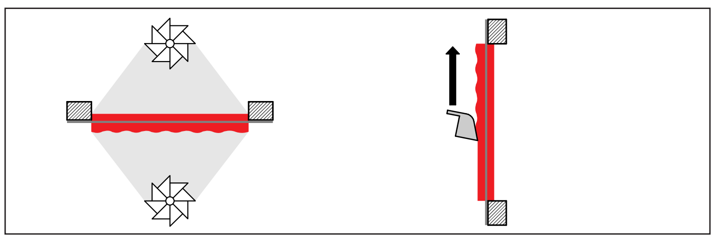
Diazo and photopolymer photo emulsions

Both types are characterised by prolonged storage capability for coated screens. Neither material represents an environmental hazard.



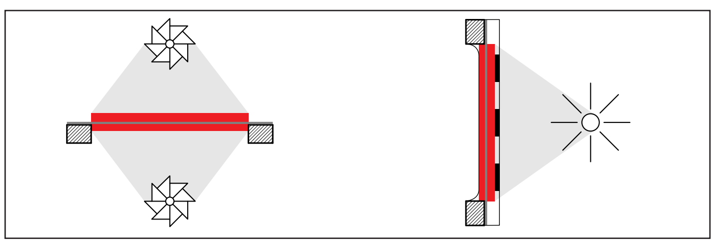
1. Coating on print side, 1–2x

2. Coating on squeegee side, 1–4x



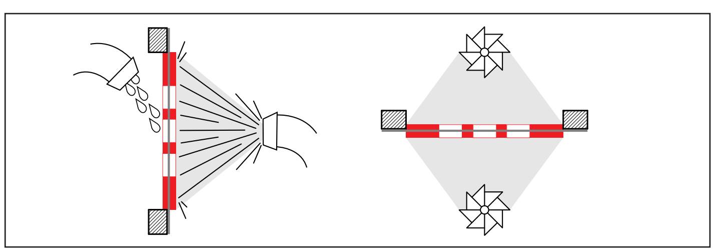
3. Dry, 85–105 °F print side down!

4. Additional coatings on print side, 1–2x



5. Dry, 85–105 °F

6. Exposure



7. Develop with cold water

8. Dry at 85–105 °F

A uniform coating is crucial to a perfect direct stencil. The mesh should be completely covered by the emulsion, with a slightly thicker coating on the print side of the stencil.

The screen is coated 1–2 times on the print side, followed immediately by 1–4 times on the squeegee side, wet-on-wet, then dried. The drying temperature must not exceed 105° F.

After drying, surface quality can be significantly improved by 1–2 additional coatings that are allowed to dry between coating.
The depth of the surface roughness should be less than 10% of the mesh thickness.

With very coarse meshes of 13–110 TPI, the screen can, after intermediate drying, be given 1–2 additional coatings as well on the squeegee side. This improves the stencil life.

The number of coatings depends on various factors, partly influenced by the particle content and viscosity of the emulsion, and also by the fineness of the mesh and the demands of the printing job.

Coating thickness vs. printing job

Lines:	Sharply defined prints are attained with a coating thickness of 10 –18 µm on mesh with 230 TPI and finer.
Rule-of-thumb:	Coating thickness on the printing side approx. 10 - 20% of the mesh thickness. The Rz value is determined using roughness depth measuring equipment. This value represents the average of the highest and lowest points on the surface (see chapter 10).
Halftones:	The thinnest possible coat of 4 – 8 µm results in the thin ink volume required for half-tone prints.
Rule-of-thumb:	Coating thickness on the printing side: approximately 10% of the mesh thickness. Roughness depth less than the coating thickness.
UV inks:	When printing with UV inks, the ink volume should generally be as low as possible. As a rule, the coating thickness on the print side of the screen should not exceed 5 µm.

The fineness and quality of the mesh are the determining factors for the number of stencil coatings.

Mesh fineness

Mesh Specification	Mesh-opening	Open area	Mesh thickness
305-34 PW	45 µm	29.6 %	55 µm
380-34 PW	23 µm	12.1 %	55 µm

These examples clearly depict the differing open areas in % in mesh of similar thickness. The larger mesh-opening causes more emulsion to be pressed through the mesh per coating. Achieving the same coating thickness on both mesh requires a different number of coatings.

Mesh quality

Mesh Specification	Mesh-opening	Open area	Mesh thickness
305-31 PW	51 µm	37.9 %	48 µm
305-34 PW	45 µm	29.6 %	55 µm
305-40 PW	37 µm	20.1 %	65 µm

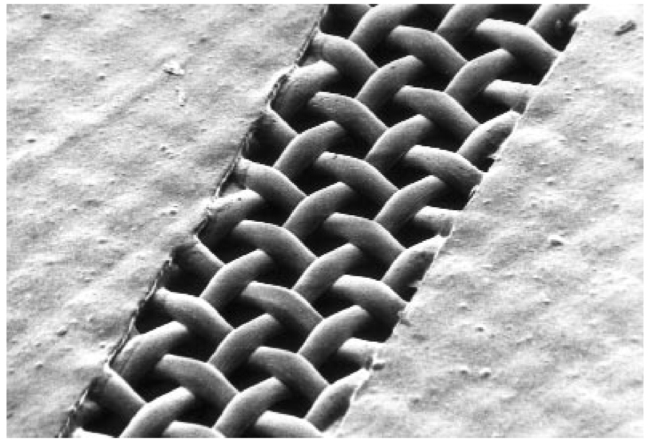
Various mesh qualities in the same number also influence the coating thickness, because of differences not only in the mesh opening but also in the mesh thickness.

Example: number of coats:

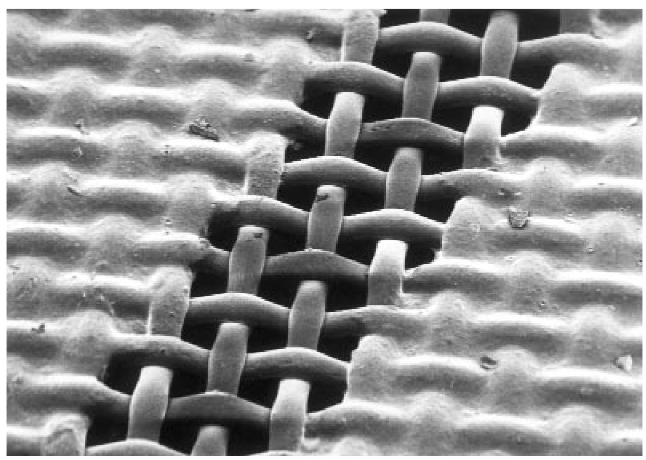
Mesh Specification	Open area	Mesh thickness	Coating wet-on-wet D / R
305-31 PW	37 %	53 µm	2 + 2
305-34 PW	30 %	61 µm	2 + 3
305-40 PW	22 %	66 µm	2 + 4

The screen should be coated immediately after degreasing, to avoid recontaminating the mesh with dust, etc. The mesh must be perfectly dry before coating.

Coating example



Correct coating



Coating too thin

The easiest way to apply the photo emulsion onto the mesh is with a coating trough. The coating edge must be rounded, and should be cambered over its entire length. This guarantees an overall uniform coating, even in the center part of the screen.

Pro-M Coater

Most DIAZO sensitizers and, consequently, the sensitised emulsions, are strongly acidic. Therefore, photo emulsions should be applied only with a V2A-stainless steel coating trough.

Warning: Aluminum is very easily damaged.

Galvanised steel troughs oxidize after a short time, which destroys the photo emulsion. This is accompanied by the formation of fine bubbles or scum, which also happens after the photo emulsion has been kept for several hours in an aluminum trough. It indicates that the emulsion can no longer be used.

Care should be taken that the photo emulsion never stays in the coating trough for longer than necessary. Covering the trough merely protects against dust and drying out.

Technical data for coating troughs:

Trough length/mm	Trough (stainless steel) profile/mm
< 50	30/30/1.5
50-150	40/40/1.5
150-1000	50/50/1.5
> 1000	50/50/2.0 - 60/60/2.0

For screen sizes over 1000 mm and a mesh of less than 51 TPI we recommend a profile depth of 60–80 mm.

Grunig G-420 Automatic coating machine for large format screens.

Grunig G-411 Automatic coating machine.

6.7 Direct stencils with film and emulsion

General procedure

Degreasing:	Before making any stencil, the mesh should be degreased with a suitable degreasing agent. Do not use household detergents.
Drying:	The mesh must be completely dry before transferring the film. To prevent later difficulties, avoid dust when transferring.
Transfer:	Place the film on a glass plate, emulsion side up. Place the frames mesh stencil, in the printing position, in contact with the film. Avoid trapping dust. Pour the sensitised photo emulsion into the stencil and sweep the emulsion over the film using a soft squeegee. Important: Wait approx. 3 minutes before putting the stencil into the dryer.
Drying:	For accurate register, dry at room temperature (max. 105 °F). Remove the plastic backing sheet after drying, and allow to dry for a few minutes longer.
Exposure:	Determine the correct exposure time through step exposures. Underexposure causes poor film adhesion, and reduced coating durability.
Developing:	Rinse with cold water.
Drying:	Dry at room temperature or in a screen drying cabinet (max 105° F). Excess water can be removed with unprinted newspaper or water suction equipment.
Retouching:	Pinholes and film edges can be covered with a water-based screen filler.

Troubleshooting direct stencils with film and emulsion

Poor film adhesion to the mesh

- Mesh used is too fine
  Mesh with low ink penetration prevents sufficient photo emulsion coming into contact with the film. The results are inadequate adhesion of the film on the mesh.
- Squeegee is too hard or too soft
  Incorrect squeegee hardness results in insufficient emulsion being pressed onto the film, leading to inadequate film sensitisation. The ideal squeegee hardness is 60 ° - 70 ° shore.
- Trapped dust
  This results from failure to clean the film with an antistatic cloth before transfer. Dust can also be a problem when there has been a delay between degreasing the mesh and applying the film.
- Exposure time too short
  This results in poor adhesion of the film on the mesh.
- Insufficient drying before exposure
  Also results in poor adhesion of the film on the mesh. Unexposed, and hence unhardened particles on the emulsion side are washed out during development.
- Copying error
  The film backing sheet was not removed prior to exposure.

6.8 Direct stencils with film and water

General procedure

Degreasing:	Before making any stencil, the mesh should be degreased with a suitable degreasing agent. Do not use household detergents.
Wetting agent:	Wetting agent encourages the formation of a uniform water film on all mesh types, to facilitate safe transfer of the capillary film.

Transfer:	The capillary film is transferrred onto the wet stencil mesh. This procedure has two advantages: 1. No additional drying time. 2. Dust problems are practically eliminated. The film is placed on a flat surface, emulsion side up. The wet mesh is carefully brought into contact with the film. The film is sucked onto the mesh through capillary action. Sweep off excess water with a squeegee. With large sizes in particular, we recommend that the film be tightly rolled, so that it can be easily unrolled on the wet upright screen.
Drying:	For accurate register, dry at room temperature or in a screen drying cabinet (max.105 ºF). Remove the plastic backing sheet after drying, and allow to dry for a few minutes longer.
Reinforcement:	Attention: For large print runs, the capillary film can be further reinforced after drying by applying emulsion to the squeegee side.
Exposure:	Determine the correct exposure time through step exposures.
Developing:	Wash out with luke warm water, concentrating on the print side until the image is open. Thoroughly rinse the squeegee side. Excess water can be removed with unprinted newspaper or water suction equipment. Dry afterwards.
Retouching:	Pinholes and film edges can be covered with a water-soluble screen filler

Troubleshooting direct stencils with film and water

Poor film adhesion to the mesh

– Inadequate water film on the print side of the mesh when transferring the film. For this reason, it is advantageous to rinse the wetting agent out of the mesh from the squeegee side, so that a homogenous film of water is formed on the print side.

– Insufficient exposure time results in poor adhesion of the film on the mesh.
– Insufficient drying before exposure also results in poor adhesion of the film on the mesh. Unexposed, and hence unhardened particles on the emulsion side are washed out during development.
– Copying error
  The film backing sheet was not removed prior to exposure.

6.9 Indirect stencils

Indirect stencils are made independently, then attached to the mesh. Indirect stencils are thin and have little influence on ink volume.

Since indirect film is exposed separately from the stencil, mesh color has no effect on exposure time or stencil edge sharpness. However, there is a uniform amount of light scatter because the exposure is made through the film substrate.

The disadvantage of indirect stencils is their loose attachment to the mesh, which makes them insufficiently durable for long print runs.

General procedure for making indirect stencils

Roughening:	New mesh should be roughened on the print side with silicon carbide 500.
Degreasing:	Before making any stencil, the mesh should be degreased with a suitable degreasing agent. Do not use household detergents.
Exposure:	The pre-sensitised indirect film is exposed through the polyester substrate. Important: Determine correct exposure time through step exposures.
Fixing:	The exposed film is fixed in a bath of hydrogen peroxide, or the manufacturer's proprietary powder. Follow the film manufacturer's instructions.

Developing: Rinse the film in warm water, emulsion side up. Follow the film manufacturer's instructions about water temperature. Rinse cold; thorough rinsing is absolutely essential.

Transfer: Place the film emulsion side up on a sand-blasted glass plate. Bring a corner of the wet stencil in contact with the film, and let the film draw itself up onto the mesh. Remove excess water from the squeegee side, using unprinted newspaper.

Drying: Drying must be at room temperature. When thoroughly dry, remove the polyester backing sheet.

Retouching: Pinholes and film edges can be covered with a water-soluble screen filler.

Troubleshooting indirect stencils

Poor film adhesion to the mesh:

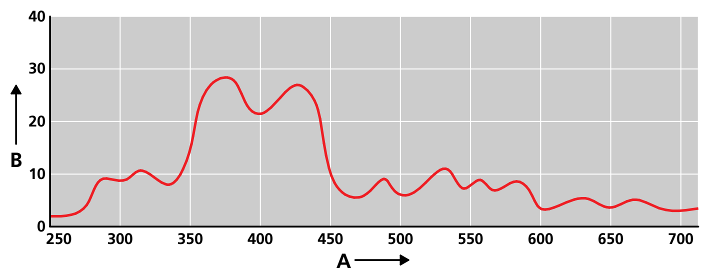
– Insufficient pre-treatment of the mesh
  Mesh must always be roughened on the print side with silicon carbide 500. Household scouring powder is an unsuitable abrasive, because the particles are of uneven size and can clog the mesh.
– Insufficient mesh degreasing
  Having mechanically abraded the mesh, it must be degreased as well. Roughening and degreasing are not the same thing!
– Excessive exposure time
  This is the main cause of poor adhesion of indirect film with the mesh. Longer exposure tends to make the film harder and more brittle, so it cannot attach itself to the mesh during transfer.
– Inactive developer
  It is best to use the developer recommended by the film manufacturer. Hydrogen peroxide deteriorates with prolonged storage.

– Drying the stencil with warm air
  Drying an indirect stencil in warm air tends to make the edges curl up. Therefore, indirect stencils should be dried only at room temperature.
– The polyester backing sheet should be removed only after thorough drying.

6.10 Exposure

Exposing the dried photosensitive layer to UV light causes uncovered areas to harden (polymerisation) and cease to be water-soluble. Unexposed areas remain water-soluble and can later be washed out using cold or lukewarm water.

Many UV light sources are suitable for exposing the photo-sensitive layer. The emission spectrum should peak in the range from approx. 350–420 nm, to coincide with the maximum sensitivity of stencil films and emulsions.



Invisible and visible light spectrum
A = wavelength
B = spectral emission W/5 nm

Suitable UV light sources are:

– metal halogen lamps from 2000 to 6000 watts
– mercury vapor lamps
– high pressure mercury lamps
– mercury halogen lamps
– super-actinic fluorescent lamps

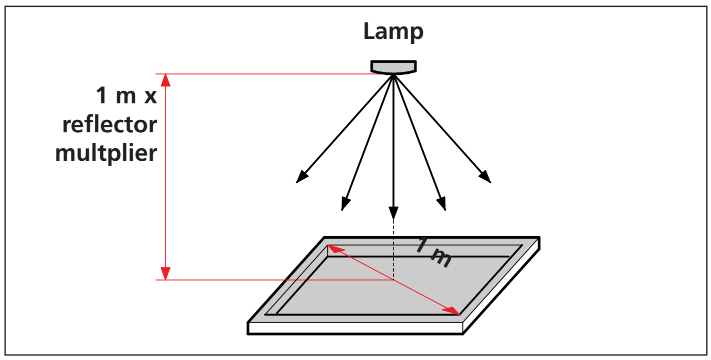
Although xenon lamps are used in offset printing, their spectral range is not sufficient for screen printing.

We recommend a single point light source for exposure reproducibility.

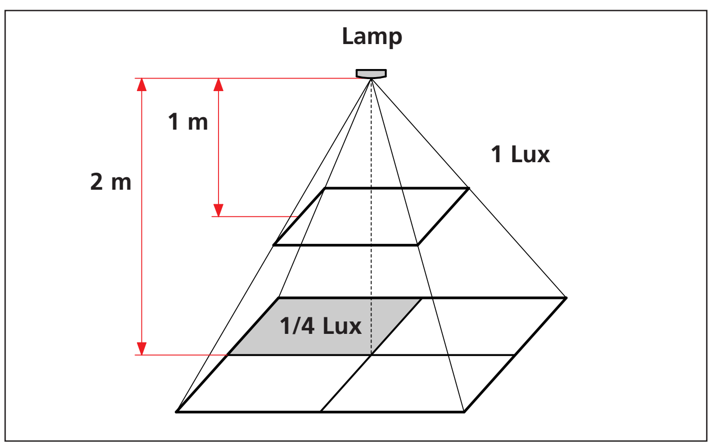
Light tubes can also be used if fine line or halftone reproduction is not required. If several tubes are stacked in parallel, their separation must be no more than the distance to the stencil.

The larger the area to be exposed, the stronger the light source needed.

The distance between the exposure lamp and the copy frame should be at least as great as the diagonal width of the area to be exposed, multiplied by reflector multiplier. In the below digram, the reflector multiplier is one. Contact the reflector manufacturer to determine the proper reflector distance.



Increasing the distance between the lamp and the copy reduces the radiant intensity in proportion to the square of the distance increase. Therefore, to maintain constant exposure, the exposure time must also be increased in proportion to the square of the distance increase.



Formula:

$$\text{New exposure time} = \left(\frac{\text{new distance}}{\text{old distance}}\right)^2 \times \text{ old exposure time}$$

Example:

new distance = 60″ (150 cm)
old distance = 40″ (100 cm)
old exposure time = 1 minute (60 seconds)

$$\left(\frac{60"}{40"}\right)^2 \text{x 60sec.}=1.5^2 \text{ x 60sec.}= 2.25 \text{ x 60sec.}=135\text{sec.}=2\text{min.}15\text{sec.}$$

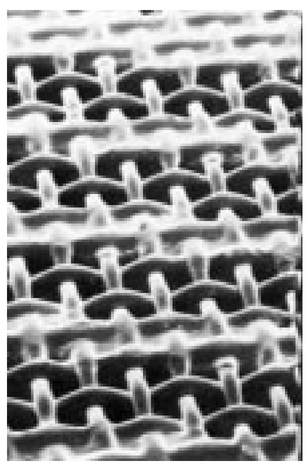
The new exposure time is thus 2 minutes 15 seconds.

Bear in mind that colored mesh requires longer exposure times than white mesh.

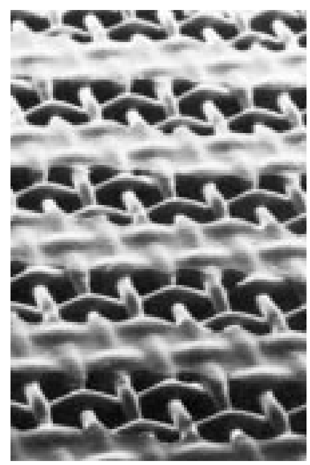
Tests with step exposures are therefore vital to determining the correct exposure time.

We recommend using an integrator for the following reasons:

– to compensate for light intensity at various distances.
– to compensate for reduced light intensity caused by lamp ageing.



Exposure too short (squeegee side)



Correct exposure (squeegee side)

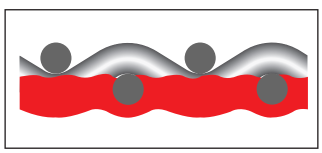
6.11 Step exposures

Step exposures are a means of determining the optimum exposure time. Correct exposure time depends on the characteristics of the photo emulsion or film, the mesh, overall thickness, the light source, and the distance between the lamp and the material to be exposed.

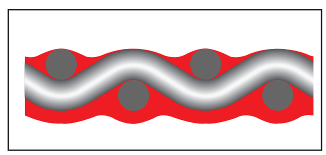
Underexposed stencils do not harden all the way through; photo emulsion on the squeegee side is washed away during developing. A smudged photosensitive layer is a sure sign of underexposure. With inadequate rinsing, some of the dissolved photo emulsion sticks in the open parts of the stencil. A barely visible scum is left behind after drying, which blocks ink flow during printing.

Underexposed stencils also have poor resistance to solvents, printing inks and mechanical wear. The stencil is also difficult to reclaim afterwards.

Overexposed stencils may suffer from reduced resolution; this is especially noticeable with white mesh. The un-dyed threads of the white mesh reflect light during exposure, which rapidly leads to undercutting problems.



Underexposed



Correctly exposed

Making a step exposure

A step exposure is best made with a test positive containing at least 5 identical images featuring positive and negative fine lines and half-tones.

5 times are chosen, progressing through 50% – 75% – 100% – 125% – 150% of the nominal exposure. If the nominal exposure time is unknown, this must be calculated from the emulsion manufacturer’s data.

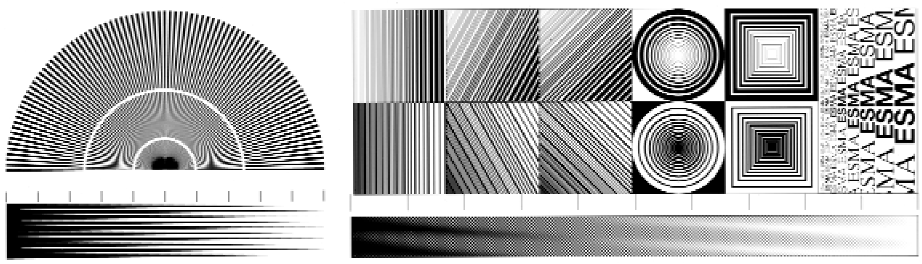
The test positive is placed on the stencil, emulsion side down, and placed in the vacuum frame. Once the vacuum has established firm contact between film and stencil, all five images are exposed for the first step (50%). One image is covered up, and the remaining four given a further 25% exposure. The second image (75%) is then covered as well, and the remaining three given a further 25% exposure. The third image (100%) is then covered as well, and the remaining two given a further 25% exposure. The fourth image (125%) is now covered, and the last image given a final 25% exposure. This provides the fifth step (150%).

During development, it becomes apparent that different exposure times produce a varying degree of stencil discoloration. The difference between steps is especially visible if the first two steps (50% and 75%) are underexposed. There should be no color difference between the remaining steps (100%, 125% and 150%). We can therefore assume that step three (100%) is the minimum exposure time. At step three, the stencil should no longer be smudged on the squeegee side. This indicates a correct stencil hardening.

Should there be a color difference between the fourth and fifth steps (not hardened through), make another step exposure based on a longer exposure time. On the other hand, when there is no color difference between the first and second steps (already hardened through), make another step exposure based on a shorter exposure time.

With diazo coatings, the color difference between individual steps is highly recognizable. The effect is more subtle with pure photopolymer coatings, although it is possible to judge exposure based on the presence of smudging: no smudging = hardened through.

ESMA test film



The ESMA test film is designed for checking the optimum exposure time for stencil-making.

Discoloration through a step exposure (no halftone factors) is used to find the best compromise between hardening and optimum resolution (sharp details).

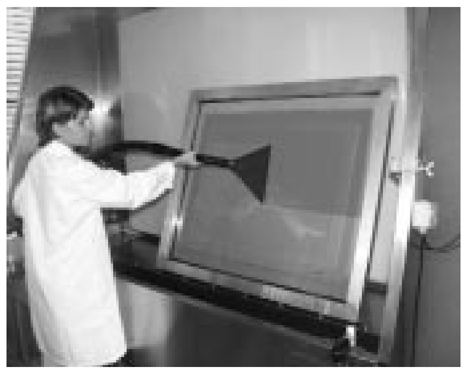
The test film incorporates the following features:

- five identical images for step exposures
- positive and negative details
- radial lines from 0.5mm to the limiting resolution of the silver film
- circular lines, and straight lines at varying angles
- various line widths (0.025 – 1.00 mm)
- text at various sizes
- raster ruling 60 lpi / 45° / tone values 0% – 100%

6.12 Rinsing

For rinsing an exposed stencil, we recommend using a nozzle where the water pressure can be regulated.

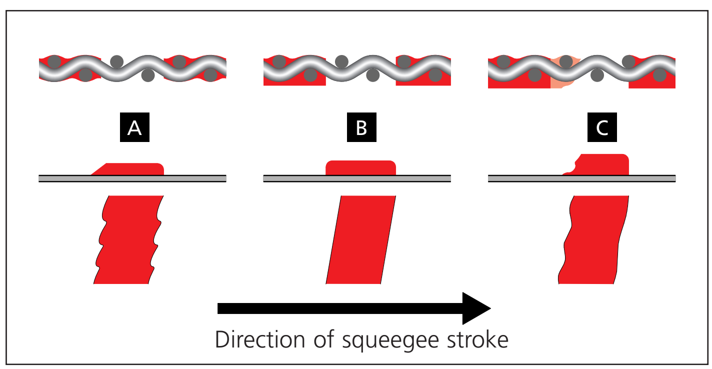
A water suction unit withdraws excess water from the stencil. This prevents scum formation (clouding) and considerably shortens the drying time.



Rinsing trough with water suction equipment

Small screens can be drawn over a stationary water suction nozzle.

6.13 Influence of coating thickness on print sharpness



A) stencil too thin	→	*sawtooth effect*
B) correct stencil	→	*sharp print*
C) stencil too thick	→	*unclear print*

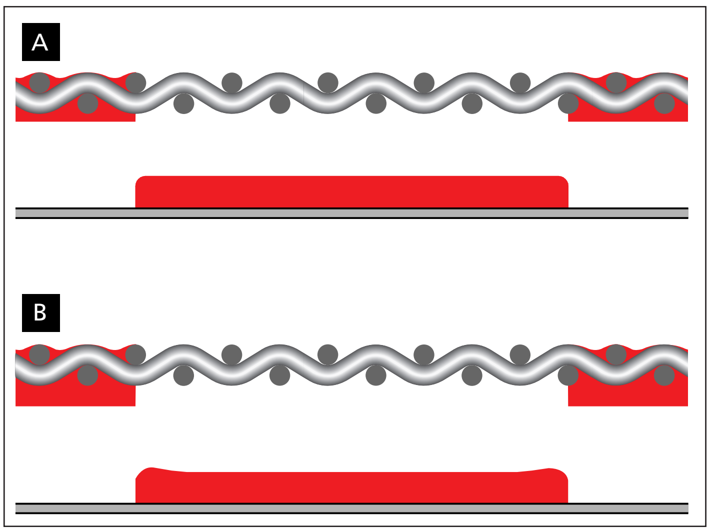
Stencils with direct or indirect film system

Stencils using these film systems print the thinnest ink layer (3–5 µm stencil profile on the print side of the mesh) without a saw-tooth effect. The film coating bridges the screen mesh evenly. The problems shown under A, B, and C are therefore less important (assuming the correct choice of mesh and film thickness).

6.14 Influence of stencil thickness on ink volume

Printing open areas

When printing open areas, and line widths exceeding approximately. 0.06 inches, the squeegee can press quite hard onto the substrate. A thick stencil will then give an elevated ink volume at the edges of the area to be printed. (B)



A) correct stencil → uniform ink volume

B) stencil too thick → higher ink volume at the edges

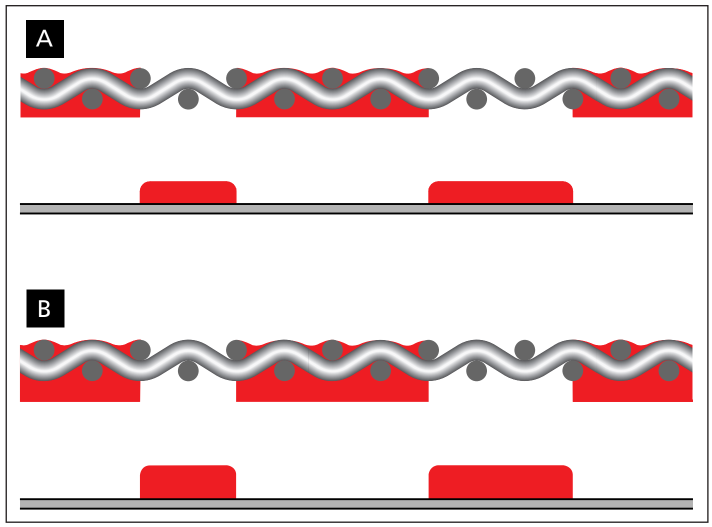
Halftones and fine lines

Stencil thickness heavily influences ink volume in halftone printing. The halftone dots support the mesh over the entire area to be printed. The greater the stencil thickness, the higher the ink volume.

A stencil that is too thick causes:

– loss of print in the light areas, and smudging of the dense halftone areas (change of tone values)

– incorrect color reproduction due to the high ink volume.



A) correct stencil → good ink volume

B) stencil too thick → ink volume too high

6.15 Hardening stencils for printing water-based colors

General procedure

- Exposure and development as with graphic stencils
- Retouching with the same emulsion, or a special lacquer
- Dry and re-expose
- Brush hardener onto both sides, allow it to react for 15–20 minutes
- Air blow or vacum the mesh free

Hardening procedure

Textile and ceramic printing generally use water-based inks. Screens are made using photo lacquer, i.e. emulsions that can be processed in the normal way and given a final chemical treatment to make them resistant to water and chemicals.

Hardener may be applied using a wide brush (not a polyamide brush), a felt squeegee, or a sponge. Hardener is evenly applied to both sides of the horizontal stencil.

Attention: have as little excess as possible!

It is important for the hardener to penetrate the coating before the stencil is finally fixed. It should therefore rest for approximately 15–20 minutes at room temperature. Thereafter, it can be finally hardened by heating at 125 °F for 1 hour, or leaving at room temperature for 24 hours.

After final hardening, the stencil is practically insoluble and cannot be removed from the mesh by chemicals generally used in screen printing.

Be sure to follow the lacquer manufacturer's instructions.

Attention: Most hardeners are acidic, which makes them detrimental to nylon mesh. Polyamides are sensitive even to weak acids.

Note: This kind of stencil hardening process is generally used for printing water-based inks used in graphic and ceramic screen printing.

6.16 Reclaiming

After printing, ink is washed off the screen with the recommended cleaning fluid.

Reclaiming is best done immediately after printing, before the cleaning fluid has a chance to dry with any ink particles left on the screen.

Reclaiming process:

– Wash the screen until the screen filler is removed.
– Apply reclaiming agent to both sides of the screen, until the emulsion dissolves.
– Wash clean with a high-pressure water jet (725-1450psi,1-2” distance)
– Remove any remaining ink deposits with special solvents.

Again, we recommend following the film and emulsion manufacturer’s instructions.

7. Register

7.1 Summary of key recommendations

Mesh

- High-modulus POLYESTER
- Dimensionally stable
- Unaffected by heat and humidity
- Optimum handling and treatment using modern equipment

Frames (see also the chapter on frames)

- Do not use wooden frames
- Use steel or aluminum frames
- Use a profile of adequate strength
- Consider side-reinforced profiles
- Check frame flatness
- Select an ideal relationship between the printing area and the size of the frame

Stretching machine (mechanical)

- Use a stretching machine with movable clamps
- Clamps must hold the mesh without letting it slip
- Clamps must be free of old glue
- Ease the strain on the mesh by corner softening
- If possible, pre-bow the frame using suitable equipment
- Continually check the tension using a measuring device (see TETKOMAT, NEWTONTESTER)
- Observe the mesh manufacturer's recommended tension for frame size using

Stretching machine (pneumatic)

- Use a stretching machine with movable clamps
- Clamps must hold the mesh without letting it slip
- Clamps must be free of old glue
- Continually check the tension using a measuring device (see TETKOMAT, NEWTONTESTER)
- Observe the mesh manufacturer's recommended tension for frame size

Gluing

- Use a two-component or CA adhesive to prevent subsequent mesh slippage caused by temperature and solvents
- Observe the manufacturer's recommended ratio of adhesive to hardener
- Observe correct drying times
- Observe the glue's pot life

Printing

- A perfectly flat printing table is crucial
- Minimum off contact
- Minimum squeegee pressure
- Optimal lift-off conditions (consistent snap-off angle over the entire printing area)
- Squeegee speed
- Print stencil laterally (shorter squeegee travel)
- In multi-color printing, always use the same length of squeegee
- Ink viscosity

Conditioning of the working area and printing stock

- 55 – 65% RH (Relative Humidity) is considered ideal
- Room temperature 65 – 70°C
- High conveyor drying temperatures can affect the dimensions of the print stock. It is common practice to send unprinted stock through the dryer/curing unit before the first printing pass to pre-shrink the stock.

7.2 Problems of accurate register

We can define accurate register as:

- Exact congruence between an original (e.g. a diapositive) and the impression on the printing stock; in multi-color printing, exact congruence between the printed impressions of the various colors (color register); further, exact agreement of the impressions at the beginning and at the end of a printing run, or between any individual, intermediate impressions.

Accurate register further includes constant location of the printed impression on the successive, individual printed units, i.e. constant distance and angle between the printed impression and the margin edges or locating holes in the printing stock.

Absolute accuracy is unattainable in practice, and we must consequently define what we mean by ”accuracy” in screen printing. This depends firstly on the purpose and intention of the individual screen print, and secondly on the results attainable in screen printing generally. Textile screen printers, poster printers and circuit printers will each have their own ideas on the subject.

Despite this individuality of aims and means, we can and must consider all the possibilities of faulty register and for each cause determine the possible order of magnitude. This indicates which points should receive attention if register is to be improved, and in what cases it would be pointless to seek higher accuracy, since the attainable improvement would be insignificant.

7.3 The film positive

The film positive consists of a polyester base and a photographic emulsion. As temperature and humidity rise, the film spreads, principally by swelling of the emulsion. The polyester base itself can be considered unconditionally stable for screen printing purposes. Cellulose-based layout or mounting foils are not recommended.

The polyester film most commonly used for film is positives is approximately 4 mils thick. A temperature increase of, say, 5°F causes it to shrink by approximtely 4-5 mil per yard. However, it expands by about 7-8 mil per yard in response to a 10% increase in relative atmospheric humidity (RH). A similar drop in temperature and humidity causes the polyester film to respond in the opposite sense. Any hysteresis effect can be disregarded. (Temperature and RH are considered separately; it should be remembered RH falls with rising temperature and constant absolute humidity.)

The 7 mil polyester film base frequently used in circuit printing responds to temperature changes in a similar way to the thinner film. However, the RH change mentioned above causes the film to change by only 6 mils.

The comparatively insignificant dimensional changes in film material are of little importance in screen printing, considering the far greater dimensional changes in the printing stock, especially paper and cardboard (see the section on printing substrates, below).

7.4 The stencil

Steel and light alloy frames

Stencil frames are of considerable importance in securing accurate register.

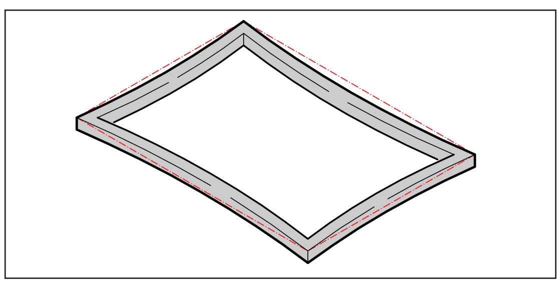
a) The linear coefficient of thermal expansion

Given our standard temperature increase of 5°F, which we have adopted for practical reasons, a steel frame expands by about 2.2-2.5 mils per yard. Aluminum frames expand by about double this amount.

b) Frame distortion by mesh pull

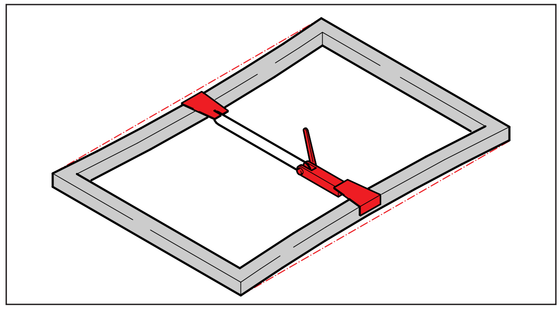
Screen printing mesh stretched to about 20 N/cm exerts a pull of around 11 pounds on every inch of the frame (i.e. every inch of the mesh edge). This works out at around 400 lbs. per yard.

For instance, consider the straight longitudinal section of a DIN A0 steel frame, with a mid-side bow of about 12 mils due to the tension in the stretched mesh. The polyester mesh, initially strained to about 2% elongation, will lose 1/4 of its stretch. The bow increases more than linearly with increasing size, even with the usual reinforced section (reference recommended frame sizes and profiles).

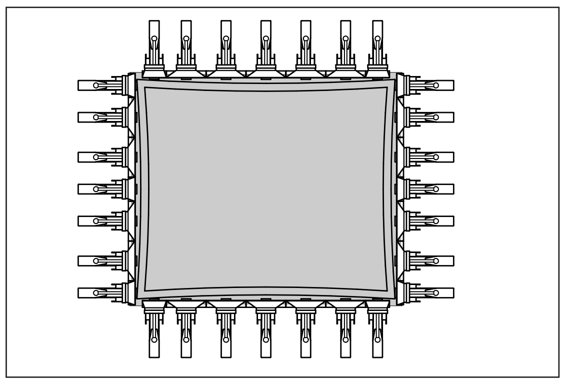


Concave frame

A permanently bowing frame has less influence on register than a fluctuating bow. The fluctuations depend on the stability or rigidity of the frame, the stability of the mesh, and the distance between the screen and the printing stock. Fluctuations can be minimized in practice by applying pre-bow to the frames:



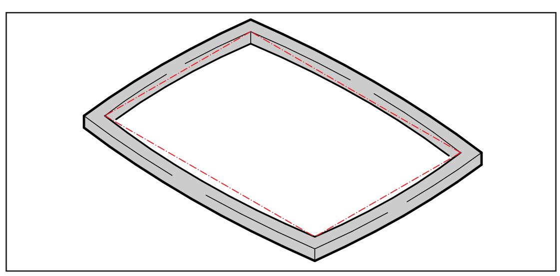
Mechanical pre-bowing device



Pre-bowed frame with SEFAR clamps

Before gluing the mesh, the frame is given sufficient concave curvature either by a strap, or the force of the stretching clamps as they prop themselves against the outside edge of the printing frame. Mesh pull and frame tension thus balance each other.

It is possible to give the long sides a convex bend of approximately 18 mil. per yard during frame fabrication, then welding them at this angle which is slightly in excess of 90°.



Convex frame

Frame warping under various mechanical stresses

The mesh exerts a powerful pulling force. Depending on the means of securing the frame in the printing machine, the danger of frames becoming warped in use should not be underestimated. Rough handling of printing frames is another common cause of warping. Warped or twisted frames always give difficulties with printing, and in obtaining correct register. The distance between the stencil and the print substrate becomes non-uniform, which interferes with squeegee pressure and uniform ink release.

This defect cannot be corrected merely by selecting a frame with a stable cross section. Levelling frames during manufacture or repair requires a very expensive levelling plate or slab, which should be part of every good frame manufacturer's equipment.

Steel versus aluminum

Steel used for screen printing frames has a specific gravity of about 7.8, light alloys about 2.7, or only about 1/3 the weight. On the other hand, sections and sides of aluminum frames have to be somewhat thicker than steel frames.

The high weight of large steel frames is a disadvantage, both for labor and equipment. There can be especial difficulties when a hinge of a hand printer is too weak to hold the frame, on one side only.

To achieve satisfactory bonding of adhesive to the frame, aluminum requires heavier roughening than steel.

Virtually all screen printing frames are now blasted with sand or steel. Steel frames are protected by galvanizing or two-component lacquer. New aluminum frames must be cleaned with solvent (e.g. alcohol-based cleaner) before glue is applied for the first time.

Recommendations for frame size and profile

In machine printing, squeegee motion is usually in the direction of the frame width, in other words, contrary to the usual practice in hand printing. The size of the ink rests, along the sides and in particular at the top and bottom, has to be determined by experiment for every printing machine. Ink reservoirs that are too small give rise to a range of problems, including uncertain register and smeared print. The sizes a machine can use have to be determined through individual trials.

Insufficiently strong frame profiles inevitably lead to problems such as:

– loss of tension at the center of the printing area
– poor register
– reduced stencil life, etc.

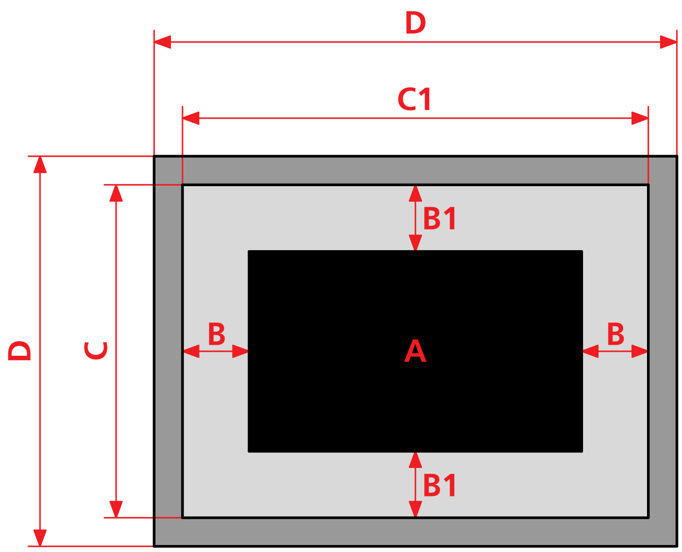
The following table shows the amount of frame flexing (inches) for a given profile and frame length (inches) under a given tension (N/cm).

Example:
A frame 40 inches long fabricated from15.7 x 11.8 x 1.0 inhes profile under a load of 18 N/cm will flex by 0.037 inches or 37mils.

Profile	Edge length 40 inches		Edge length 80 inches		Edge length 120 inches	
(Inches)	18 N	28 N	18 N	28 N	18 N	28 N
1.18 x .79 x .079	0.037	0.057				
1.57 x 1.57 x .067/.110	0.030	0.046				
2.36 x 1.57 x .098/.118	0.011	0.017	0.17	0.26		
3.0 x 1.5 x .125			0.059	0.091	0.30	0.46
4.0 x 1.5 x .125/.312			0.033	0.052	0.17	0.26

Frame flex in inches

Frame size and profile sections:



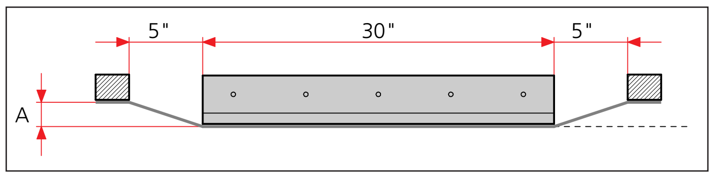
A Printable area in inches	B / B1 Free mes side/top in inches	C / C1 Frame outside dimensions in inches	Aluminium sections and wall thicknesses in inches	Aluminium sections with various wall thicknesses in inches
8.5x 11	6.0 / 6.0	15.25 x 18.75	1.50 x 1.50	1.57 / 1.57
11 x 17	6.0 / 6.0	18.75 x 27.25	.0625- .125	.067 x .110
17 x 22	6.0 / 6.0	28.3 x 31.5		
24 x 36 34 x 44	6.5 / 6.5 .25 / 7.2	40.0 x 56.25 53.25 x 67.5		1.57- 2.36 .098 x .118
47 x 63	.75 / 7.7	63 x 79		1.57 x 2.36 .098 x .118
55 x 71	8.5 / 8.5	71 x 87	3.0 x 1.5 0.125	
63 x 83	9.8 / 9.8	81 x 101	4.0 x 1.5 0.125	4.0 x 1.5 .125 x .312

Screen printing mesh

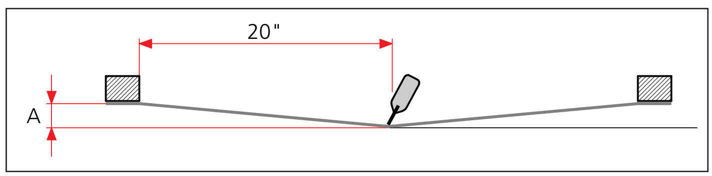
Non-contact printing with lift-off necessarily distorts the stencil carrier, even before consideration of the mesh shift caused by the squeegee action. The change or distortion of the impression depends primarily on the distance between the stencil and the printing substrate (off contact).

Mesh distortion as a function of the off contact distance:

Internal screen dimension: 40"



Mesh distortion "V", front view:
A = 0.004"   V = 0.0003"
A = 0.008"   V = 0.0013"
A = 0.012"   V = 0.0028"



Mesh distortion "V", side view:
A = .004"   V = 0.000008'
A = .008"   V = 0.000315"
A = .012"   V = 0.000709"

The friction of the squeegee on the stencil leads to a shifting or distortion of the imprint in the direction of the squeegee motion. Register inaccuracies are influenced by:

- ink viscosity
- squeegee pressure
- squeegee shape and position
- squeegee hardness
- printing speed
- surface condition of the printing substrate
- screen stability

This requires investigation of the qualities of the stencil carrier (mesh) in regard to elongation resistance.

a) Polyamide

Even with maximum stabilization, nylon mesh (polyamide), cannot achieve the stretch resistance of polyester mesh. They are primarily used for printing curved surfaces, where high elasticity is desirable.

b) Polyester / steel

For precision-register prints, especially in larger sizes, the choice is between polyester and steel (V2A) screen mesh. Steel has even higher stretch resistance than polyester. Nevertheless, polyester stencils are often preferred because, correctly tensioned, they satisfy register requirements and are less sensitive to blows and shock.

It is impossible to specify reliable coefficients for register differences and the differences between polyester and steel mesh, since other factors previously mentioned always interfere. Numerous comparative tests have been made, particularly by circuit printers.

Steel's higher susceptibility to fatigue is well known in practice, but cannot be quantified.

c) Mesh strength

The strength and stretch resistance of a monofilament thread increase in proportion to the square of the diameter, while the strength of the mesh only increases in linear proportion to the mesh count.

A mesh woven from relatively thick threads is thus more stretch resistant and prints with better register. The choice of mesh count, and thread diameter depend on the fineness of the print, the desired ink volume, and mesh permeability.

d) High-modulus polyester mesh

High-modulus polyester mesh types are characterized by increased strength and dimensional stability. They find use in virtually all screen printing applications.

e) UV mesh for printing UV inks

Calendered (i.e. heat-flattened) mesh offers less resistance to squeegee motion, hardly move, and promote good register. Calendering inevitably reduces the mesh opening, which can be desirable for very low-viscosity lacquers and UV inks.

f) Static electricity

Electrostatic charging of polyamide and polyester mesh is prevented by pre-treating the mesh during manufacturing on the one hand, as well as by appropriate conditioning of the working area (RH > 55%). Lonisers and anti-static additives in printing ink can limit the build-up of electrostatic charge during printing.

Optimal mesh tension

1) Degree of stretch:

See also the chapter on mesh stretching.

The tensioning force is limited by the nature and capacity of the stretching equipment, but even more so by the strength of the mesh and the rigidity of the printing frame. Mesh woven from high-viscosity polyester can be stretched to extraordinary levels. Very high mesh tension allows a small distance between the screen and the printing stock, and precise adjustment of the squeegee pressure.

The degree of tension can be measured in different ways:

a) pressure gauge on pneumatic stretching equipment
b) measuring elongation of a predetermined length of mesh before and after stretching (2–4% elongation for polyester mesh, 4–6% for polyimide)
c) using instruments that measure the sag of the mesh under applied weight, and display the result scaled in mm or N/cm (NEWTONTESTER, TETKOMAT)

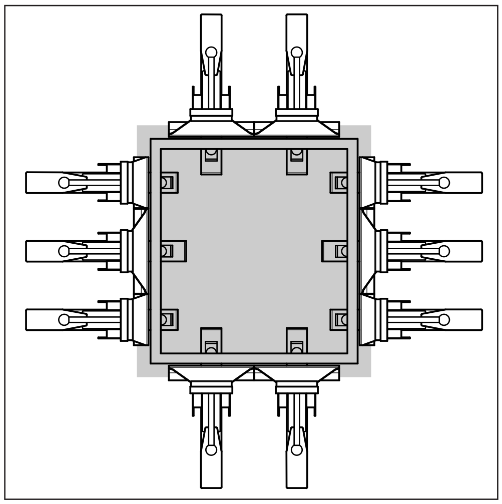
Good quality mesh types have the same stretch resistance in warp and weft, and do not require different degrees of stretching. Differing tensions can be useful in very narrow or curved frames, as used for printing skis, as well as in rotary printing.

2) Choice of stretching machine:

Pneumatic stretching equipment is recommended for best register precision. Pneumatic stretching equipment requires minimal adjustment once the mesh is at tension. Mechanical stretching equipment is more operator intensive, requiring additional labor to continue to stretch mesh to maintain tension.

3) Pneumatic tensioning:

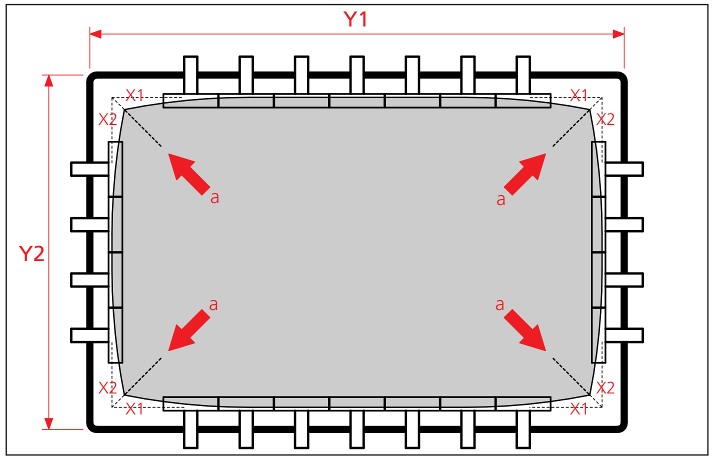
The mesh must be clamped parallel to the warp and weft threads. Take care that the sum total of the clamp lengths does not exceed the length of the printing frame. The clamps should line up flush beside each other, and pull uniformly and simultaneously at the mesh. Unsynchronized clamp movements produce shear forces that can tear the mesh. The stretching equipment must be extremely well treated and maintained.



Stretching with pneumatic clamps

4) Stretching with mechanical machines:

The mesh must be clamped parallel to the warp and weft threads. Mesh is pulled out a little from the corner clamps, to avoid local over-stretching (see table).
The clamps must hold the mesh gently enough not to cause damage, but tight enough to avoid slippage. The warp and weft must be stretched to the same tension.



a = pocket

SEFAR® Pecap LE	Corner softening at positions X1 and X2 for maximum tensioning force of:		
Frame length Y1 or Y2	10 N/cm	20 N/cm	30 N/cm
1 yard	.18 inches	.36 inches	.54 inches
2 yards	.36 inches	.54 inches	.72 inches
3 yards	.54 inches	.72 inches	.90 inches
4 yards	.72 inches	.90 inches	.98 inches

Gluing mesh to the printing frame

1) Frame pre-treatment:

The adhesion surface of new frames must be roughened and degreased. Old glue should be removed from used frames where possible. Sharp edges and corners must be smoothed down.

2) Solvent-proof adhesives (two-component glue):

Adhesive Characteristics:

- easily spread, approximately 1 hour pot life
- drying time (depends on mesh count and mesh thickness)
- mechanical tensile strength 175-200 lbs per 4 inches of selvedge
- solvent-proof within less than 24 hours
- hot water proof (max. 70°C)

7.5 The printing substrate

Importance of air and material conditioning to the dimensional stability of the material to be printed.

Composition

Composite substrates that have been woven, coated or laminated from several materials should undergo an ink test to determine dimensional changes brought about by the ink and solvents (curling/buckling).

Conditioning

Optimum climactic conditions exist for achieving high-quality results on paper and cardboard.

It is extremely important to allow the substrate to become acclimatized to the environment in the print room. If possible, atmospheric conditions should be the same in the print room and in the warehouse.

Paper and cardboard

1) Effect of temperature:

   Normal changes in room temperature have surprisingly little effect on paper and cardboard characteristics by themselves. (Printers require a certain temperature level and stability more because of ink viscosity and drying characteristics.) However, temperature affects the relative moisture content of the printing substrate, which is extremely important.

2) Effect of relative humidity:

   All vegetable fibers, of which paper and cardboard are made, are hygroscopic. Water absorption strongly depends on the quality of the paper.

   Rag papers (made from textile waste) absorb the least water, cellulose (wood pulp) is somewhere in the middle, and mechanical pulp absorbs the most moisture of all.

   Water absorption is increased by heavy milling, and reduced by high filler content. Paper’s hygroscopic behavior further depends on its preconditioning. If the paper has been previously dried, it will absorb less water than if it has been left moist (hysteresis).

The wet elongation curves for the papers mentioned above are all S-shaped, i.e. they are flattest between 40 – 60% relative humidity. Moreover, elongation is less along the paper's manufacturing length than across its width, because the fibers tend to orient themselves in the machine direction and fibers swell many times more diametrically than longitudinally. Papers with closely compacted fibers spread more.

During manufacture, a paper is exposed to stresses that may remain largely latent. As soon as the paper becomes softened by moisture, it tends to contract in the machine direction while expanding transversely.

Degree of elongation

As a rule of thumb, it can be assumed that under working conditions of around 50% relative humidity, a change of 10% will cause the following dimensional changes in the printing stock:

– transverse to the machine direction: 0.028-0.036 inches per yard

– longitudinally to the machine direction: 0.108 inches per yard

The average dimensional changes between 20% and 80% relative humidity (e.g. for SK* 95 g/m^2 offset paper) can be estimated at:

– transverse: 0.045 inches per yard

– longitudinal: 0.017 inches per yard

for a 10% change in relative humidity.

Plastics

Here again, it is first necessary to establish whether the printing base consists of a single material or a composite: e.g. whether a foil has been rolled on or affixed to a backing. The foil to be printed may, in some cases, be so elastic that it will follow all the dimensional changes of the base or backing to which it is affixed.

The same applies, of course, to self-adhesive foils before being attached to a base, if the adhesive is covered with a protective paper.

Relatively rigid, e.g. polyester-based, foils are an exception, where fluctuating humidity can lead to bulging as the protective paper expands and contracts more than the foil itself.

Dimensional changes in plastics, brought about by temperature and humidity fluctuations, vary widely. Conductivity is generally very low, and moisture absorption proceeds so slowly that the plastic can take hours or days to respond to a change in relative humidity. Changes caused by temperature fluctuations are of more importance than those due to varying humidity, which are practically insignificant. The influence of solvents on PVC, however, has to be considered.

Dimensional change in microns/yard for a temperature variation thickness of 5°F:

– polyester	123
– PVC	320-457
– transparent acrylic	320

Glassine foils

When printing on glassine foils (transparent viscose foils, which are not counted among the synthetic plastics), considerable dimensional changes must be expected as a result of their strongly hygroscopic nature. It depends on whether these foils are unlacquered (PT foils), or lacquered with cellulose (MSAT foils) or PVDC (MXXT or K foils).

Acetate

Where accurate printing register is important, acetate foils (viscose treated with ethanoic acid) are preferred, provided no difficulties arise in regard to inks and printing procedures. The dimensional change in response to a 41°F temperature change is 640um / yard, not considering dimensional changes due to moisture.

Summary

The factors discussed affecting accurate register show that the primary stencil requisites for best printing results are:

- frame stability
- correct mesh stretching
- the stencil making method

Factors such as dimensional changes of

– polyester-based film positives
– the frame material itself
– use of polyester or steel as the stencil carrier

are less important.

Register is further influenced by:

– squeegee pressure
– squeegee hardness
– ink viscosity
– off- contact
– type of facility
– printing machine quality

Proper conditioning of the print room and printing stock are crucial when printing on paper and cardboard.

Below, we again compare the various possible dimensional changes to compare their importance. This is intended to help pinpoint sources of error whose elimination would be advantageous.

For dimensional changes caused by temperature and humidity, we use as standards:

– 5°F temperature variation, or
– 10% change in relative atmospheric humidity

We disregard the inverse relationship between temperature and relative humidity.

It should further be noted that air conditioning within tolerances of ±5°F and ±5% humidity represents an advanced standard for a modern screen printing facility, and requires highly accurate supervision. In general, the following numerical values will have to be multiplied according to the actual atmospheric fluctuations in each individual case.

Data are given in terms of microns per yard.

1) Dimensional changes induced by climactic conditions in microns

	5°F temperature change	10% rel. humidity change
Film positive, polyester 100 um thick	135	21
Film positive, polyester 180 um thick	135	16
Steel frame	65	0
Aluminum frame	13	0
Printing stock:		
Paper, transverse elongation	insignificant	approximately 731-914
Longitudinal elongation	insignificant	approximately 274

2) Mechanically induced dimensional changes:

Fluctuations in frame warping up to approximately 0.08”

Distance between stencil and printing stock:

0.12” lift-off DIN A1	impression length	25 um
	impression width	65 um
0.19” lift-off DIN A1	impression length	75 um
	impression width	180 um

Distortion by squeegee friction:

Well-stretched steel stencil	approximately 20um and over
Well-stretched polyester stencil	approximately 30um and over

Indirect stencil:

Film shrinkage through washing and drying up to approximately 30um

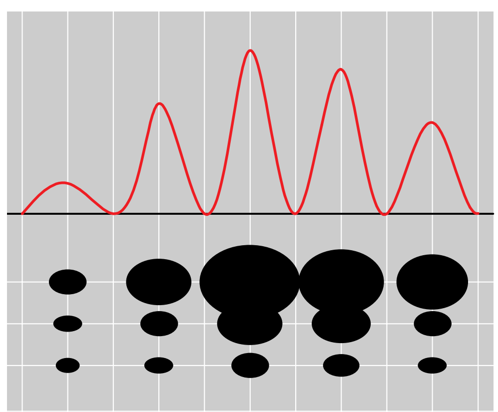
8. Halftone printing

The original artwork to be halftone printed is frequently a photographic image. Images of this kind cannot generally be raster printed in their original form: photographs are always continuous-tone images, where the gradient from light to dark has no discernible point structure.

The artwork must first be converted into a printable form. This is done by translating the continuous-tone image into halftone dots, using an AM or FM raster.

8.1 AM halftone (amplitude modulated rastering)

An area of continuous tone is resolved into a grid, with rows of larger and smaller dots. Viewed under a microscope, it becomes clear how the dot size is related to color intensity, while the distance between the dots is fixed. In other words, we have a fixed dot spacing with variable dot area. If we draw a plot of dot area on the vertical axis against dot spacing on the horizontal axis, the result is a curve whose amplitude changes according to the dot coverage, while the dot spacing remains fixed. The general shape of the curve is not unlike an "amplitude modulated" waveform, with fixed frequency and changing intensity or amplitude.



Analog raster with variable area (amplitude)

Although the printing process is inherently digital (1/0, ink/no ink), the end result is an apparently analogue (smooth tone) representation of the original image. Applied to color printing, the very nature of the technique encourages moiré patterns. Counter measures, such as angling the individual color separations, are required to minimise the moirés inevitably produced by multi-color printing.

8.2 FM halftone (frequency-modulated rastering)

The ability to produce laser-generated points smaller than the smallest practicable analog raster dot opens the possibilities of emulating analogue rasters, or pursuing a new, digital half-tone model. The first laser and film recorders were designed merely to reproduce the well-established analogue raster angles and pitches. However, the technique's growing popularity has given rise to new rendering models that go under the general name of "frequency-modulated halftones".

The recording technology allows representing a continuous-tone image by varying the distribution of uniformly sized, extremely small dots. Varying coverage is achieved by varying the number of recorded dots per unit area.

20 % tone value **80 % tone value**

Conventional (AM)

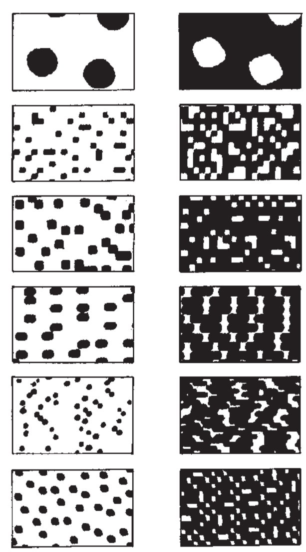
Agfa CristalRaster

Heidelberg
Prepress Diamond Raster

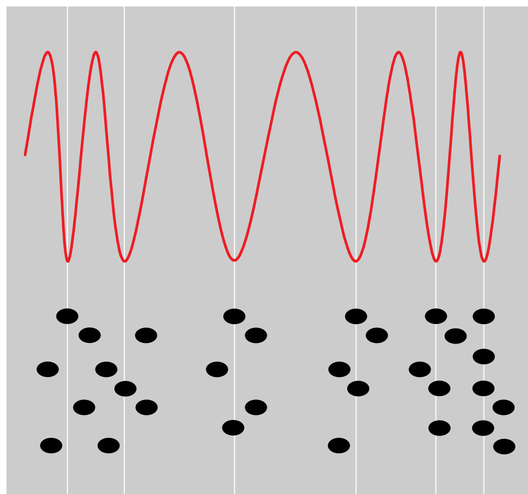
UGRA/FOGRA Velvet Raster

Scitex Fulltone

Crosfield



Examining the dots, it is clear how they are much finer distributed than with an AM raster, as well as being all the same size. If we draw a plot of dot size as amplitude on the vertical axis against dot spacing on the horizontal axis, we obtain curves of constant amplitude, but variable distance between adjacent peaks. The curve's general character corresponds to a frequency-modulated waveform – which is why we speak of a frequency-modulated raster.



Coverage and frequency modulation

Various methods have been devised for positioning the dots in an optimal manner.

On a practical level, it is clear that an FM raster results in considerably finer dots on the film, and hence uniform color coverage. It should also be apparent that this type of halftone translation virtually eliminates moiré effects. In their place come other disturbances such as clustering or heaping.

It is important for the halftone printer using FM dots to know and control the minimum printable and reproducible size. We recommend a dot diameter corresponding to at least 2 threads plus 1 mesh opening of the halftone printing mesh.

8.3 Types of halftone rulings

For a halftone image to be effective at a given size and viewing distance, one must determine a number of factors, including the type and fineness of the raster ruling.

Monochrome halftone images can be achieved using so-called ”effect rasters”. These are:

– Corn raster
– Worm raster
– Line ruling
– Circular ruling

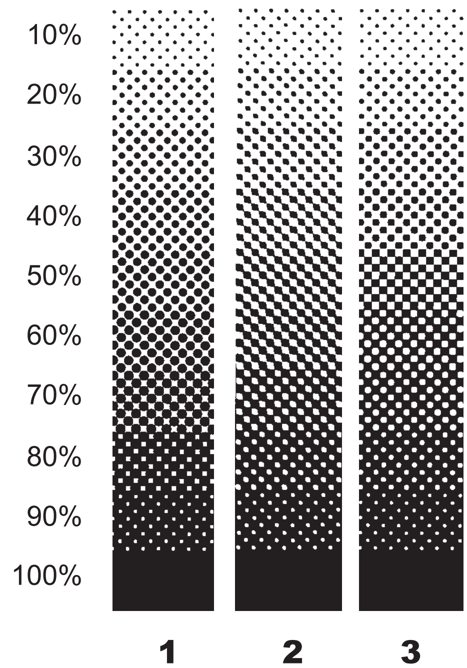
Corn raster example

The uneven structure of corn and worm rasters is less prone to moiré effects than line, point or bead-string rulings.

For textile printing, there is a long-established type of graining known as the ”DIRACOP method”. Even now, halftones are often prepared by hand, using transparent foils with a grained surface to achieve the halftone structure.

Four-color printing uses the following dot shapes:

- round dots
- elliptical dots (bead ruling)
- square dots (checkerboard ruling)



1 = Dot raster, dots blend at approximately 70 %

2 = Bead ruling, dots blend at a) approx. 40 %
b) approx. 60 %

3 = Checkerboard ruling, dots blend at 50%

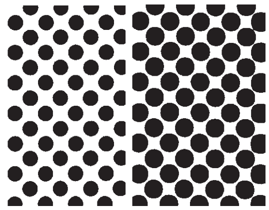
1 = Dot raster, dots blend at approx. 70 %

2 = Bead ruling, dots blend at a) approx. 40 %
b) approx. 60 %

3 = Checkerboard ruling, dots blend at 50%

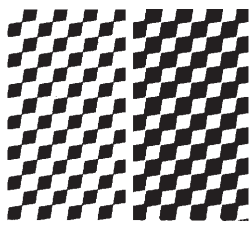
Dot transition/blending

Dot shape affects the way raster dots transition within total ranges. Here, we examine each dot shape in turn at 46% and 52% coverage respectively.



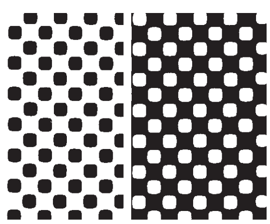
Round dots at 46% and 52% coverage, and at blending

Round dots blend at 65–70%. When this happens, though, it affects four neighbouring dots simultaneously, and this results in a steep tone value transition.



Elliptical dots at 46% and 52% coverage

With a beaded raster, the dots blend at two distinct tone values. This results in a virtually unnoticeable transition. Dot blending is direction-dependent: two neighbouring dots first chain together, then the two parallel chains combine.



Square dots at 46% and 52% coverage

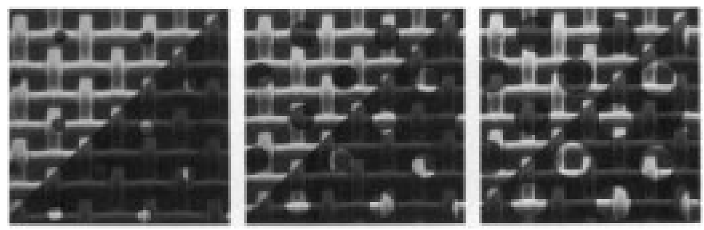
Square dots blend with four neighbouring dots simultaneously, resulting in a steep tone value transition. In halftone printing, the effect is further emphasised by the high ink deposit.

8.4 Halftone line ruling

The fineness of the halftone line ruling (lpi) is always linked with the fineness of the mesh and the type of stencil.

Mesh and halftone fineness

The finest details should properly adhere to the mesh. Areas with the highest ink coverage, i.e. where the smallest dots of emulsion must cling to the mesh, are particularly critical. The smallest points should not be allowed to rest on just one thread, or even fall through the mesh opening.



Critical dot sizes

Strictly speaking, the diameter of the smallest halftone dot on the film should be microscopically measured, in order to select a mesh of the correct fineness.

coverage lpi	5%	10%	15%	20%	30%	70%	80%	85%	90%	95%
51	126	178	218	252	309	309	252	218	178	126
56	114	162	198	229	280	280	229	198	162	114
64	101	142	175	202	247	247	202	175	142	101
71	90	127	156	180	220	220	180	156	127	90
76	84	119	145	168	206	206	168	145	119	84
81	79	111	136	157	193	193	157	136	111	79
86	74	105	128	148	182	182	148	128	105	74
102	63	89	109	126	154	154	126	109	89	63
122	52	74	90	105	128	128	105	90	74	52
137	46	66	81	93	114	114	93	81	66	46
152	42	59	72	84	103	103	84	72	59	42

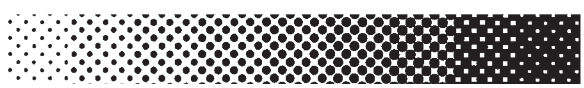


Table of dot sizes

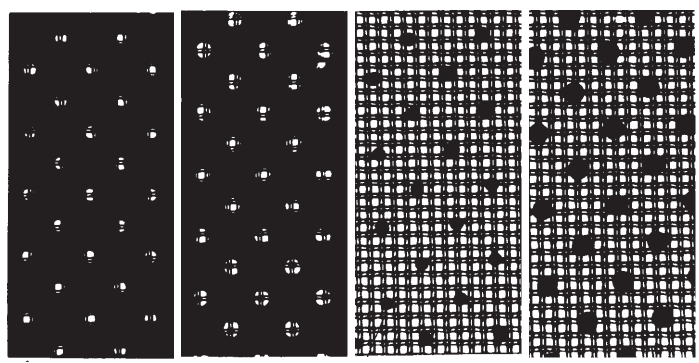
From the examples above, it is clear that the diameter of the smallest dot must correspond to two threads plus one mesh opening, if the halftone dot is to be adequately supported by the mesh.

Ink flow in shadow areas

Halftone printing is a print-through process and not – as in offset – a transfer process. The raster printing form (mesh + stencil) produces a thicker ink deposit than a litho plate. This is the characteristic and advantage of raster printing, namely, the intense and effective depth of color. In halftone printing, however, the ink deposit should be relatively thin, because the finer the line ruling and the higher the degree of coverage, the more difficult it is to avoid ink running in the high-coverage, dark print areas (smudging).

The thinner and finer the mesh, the less ink is deposited. Thinner mesh therefore is better suited for fine halftone printing.

When printing areas with low percentage coverage, the ink should flow freely through the smallest mesh openings without any obstruction from threads or stencil thickness. In this respect, a relatively light mesh is more advantageous than one with thick threads.



5% coverage *10% coverage* *95% coverage* *90% coverage*

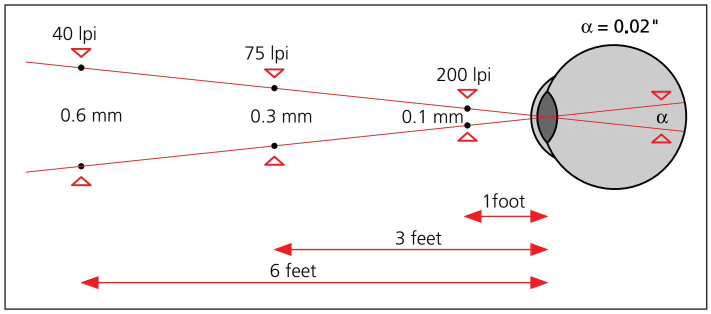
Fineness and viewing distance

The halftone simulates continuous tone in as much as the eye cannot distinguish the individual dots anymore.

Under normal conditions, the human eye discerns two adjacent points or lines as separate when their images do not impinge on two neighbouring retinal cells (rods or cones). There has to be at least one intervening retinal cell.

The dots therefore become indistinguishable when their images fall on the same or two adjacent retinal cells.

The minimum angular resolution of the human eye is approx. 0.02°.



Raster rulings discernable to the eye

Guidelines:

Image Size (inches)	Viewing distance	Halftone dots per inch
<8.5 x 11	22 inches	91-122
8.5 x 11	22 inches	61-91
11 x 17	22-44 inches	46-61
17 x 22	3-11 feet	38-51
24 x 36	7-18 feet	30-46
34 x 44	11-36 feet	30-38
>34 x 44	11-72 feet	-30

The following factors should be considered when determining whether a given print job is feasible:

– Adapt the line ruling to the surface structure of the printing material.
– Glaring or highly intensive colors require a relatively coarser raster ruling than pastel colors. The coarser the halftone ruling, the higher the contrast of the print.
– For finer or softer images, choose a finer line ruling.

From the commercial viewpoint, a halftone printer is advised to first print with course line counts to gain experience before moving on to finer halftones. When selecting a halftone line count, the viewing distance should always be taken into consideration.

8.5 Tone values of halftone dots

Tone value expresses the relative area coverage of the halftone dots compared to maximum (100%) coverage.

In offset printing, the percentage coverage of the dots can range from 95% to 5%, whereas the screen printer must be satisfied with a tone value range from approximately 85% to 10%. This applies to raster rulings of approximately 12 lpi and finer.

For a perfectly printed 15% dot, the ink must be relatively fluid in order to keep the dots open in the mesh. However, this leads to difficulty in obtaining the tonal range because the dots for 85% coverage tend to smudge if the ink is too thin. On the other hand if the ink is made more viscous, the smallest dots tend to dry too quickly and block the mesh openings.

Tone value:
Therefore, ink viscosity is a compromise in order to prevent smudging in dark areas, while permitting fine dots in the light areas of the image.

Tone value of the color separation:
For halftone raster printing, the film maker should calculate the maximum coverage for all four colors together, to reach an optimum density of 300%. For reproductions with predominantly dark areas, the color black should not attain more than 75% coverage. Yellow, however, can show higher coverage in order to produce the correct tone values for green and red.

Typically, the finer the raster ruling, the greater the difficulties will experience. This illustrates present-day limits to commercial halftone printing.

Examples for perfect reproduction of halftone values in raster printing:

up to 60 lines/inch 5-90 %

up to 100 lines/inch 10-85 %

up to 120 lines/inch 15-80 %

These examples are based on the following general rules:

The finest printable dot should have a diameter of 80–100 μm (This corresponds to the sum of 2 thread diameters + 1 mesh opening in Pecap LE 7-380-31 PW mesh).

8.6 Halftone printing process line

The process line is the characteristic curve describing the relationship between tone values on the film positive and those of the corresponding printed image.

The halftone printing process line serves as a correction guideline, which helps the printer avoid the problems that would otherwise arise in half-tone printing.

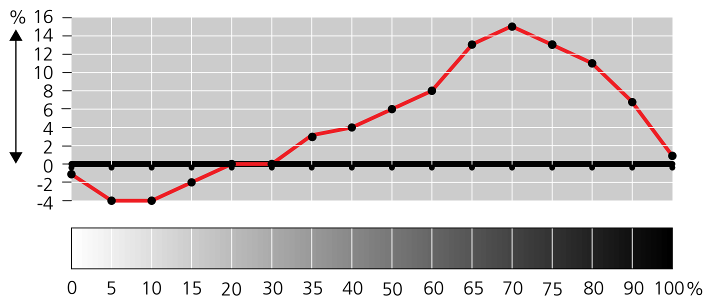
The raster printer therefore needs no measuring instrument. A halftone step wedge with at least 10 tone values should be printed alongside the artwork. The printer uses a transmission densitometer to measure the halftone values on the positive film, and a reflection densitometer on the print. The results can be compared on a chart.

Densitometer

Example of a printing process line

Film tone value %	Print tone value %	Dot gain / loss	
99	100	+1	100
91	98	+7	90
83	94	+11	80
76	89	+13	75
69	84	+15	70
63	76	+13	65
53	59	+8	60
47	53	+6	50
40	44	+4	40
32	35	+3	30
28	28	0	25
22	22	0	20
17	15	-2	15
11	7	-4	10
6	2	-4	5
1	0	-1	0

The variances in tone values, plotted as a curve, result in the so-called process line:



Schematic representation of the printing color scale

Every process line must also specify the following operational parameters:

– film	lines/inch, type
– mesh	type, threads/inch, tension N/cm
– type of stencil	emulsion, capillary film, indirect film
– stencil thickness	specified in µm
– surface roughness	Rz value in µm
– ink	type, manufacturer, composition, viscosity
– machine	type, manufacturer
– squeegee	hardness, thickness, clearance, angle, pressure
– printing stock	precise description, e.g. type of paper, etc.

The color scale can be significantly influenced by a change in any single item in the list above.

8.7 Printing control strip

The FOGRA DKL-S1 control strip has been specially developed for halftone printing, and may be used for visual and densitometric monitoring of the following:

– Stencil production
– Changes in tone values
– Color caste
– Color balance
– Dot gain

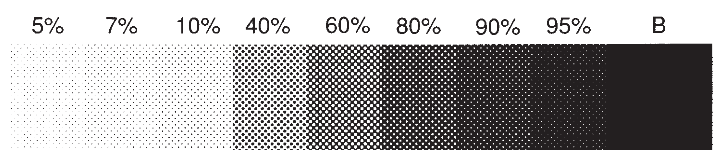
Halftone field

This area features halftone dots with coverage levels from 5% to 95%. The raster count is 61 dots/inch. This facilitates visual and (preferably) densitometric checks on tone value transfer during printing.

Full tone field

A further check, which is of utmost importance in raster printing, is to measure the intensity of the printed ink.

A reflection densitometer is used to measure the ink intensity of the four colors in the full tone fields. To achieve a good grey balance, all three process colors must lie within a close tolerance range.



Raster and full tone

Example full tone measurement:

Color	Required density	Tolerance
CYAN	1.45	± 0.10
YELLOW	1.00	± 0.05
YELLOW 47B	1.40	± 0.10
MAGENTA	1.40	± 0.10
BLACK	1.85	± 0.15

Measuring instrument: Densitometer

Printing stock: Artistic printing papers

Overlaid printing fields M/Y, C/M, C/Y, and C/M/Y

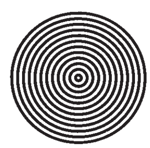
These areas allow color acceptance to be assessed both visually and by measurement. It is important to use the same print-color sequence for proof prints as well as for the production run.

M/Y C/M C/Y C/M/Y

Overlaid print

Ring field

This allows monitoring of transfer errors during printing, which can be caused by smearing effects.

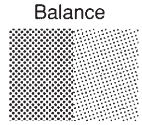


Ring field

Balance field

The combined three-color print in the balance area should be a neutral grey, with a tone value approximately equal to the 40% half-tone field. This is a very sensitive indicator of shifting color balance during a print run.

Balance



Balance field

8.8 Types of stencils

Generally speaking, one can use any kind of stencil for halftone printing. However, one should take into consideration a few points that are typical for this kind of printing.

The difficulty with printing single or multi-colored halftones is that both light and dark areas must be neatly printed. There should also be no shifts in tone values. To maintain a perfect tonal range, the stencil emulsion should be as thin as possible.

The preferred stencils for halftone printing are therefore indirect stencils, or direct stencils with film and water (capillary film), and minimal film thickness.

Direct stencils with photo emulsion are also used for long press runs. However, it is essential that they have a thin coating (5–10% of mesh thickness) and low Rz value (less than the coating above the mesh in µm).

Important: Direct stencils should use yellow dyed mesh to avoid light scatter during exposure.

Only impeccable film positives are suited for halftone work. For correct reproduction of the complete range of tone values, it is essential that all the dots are completely opaque right up to their edges. (See chapter 5.4)

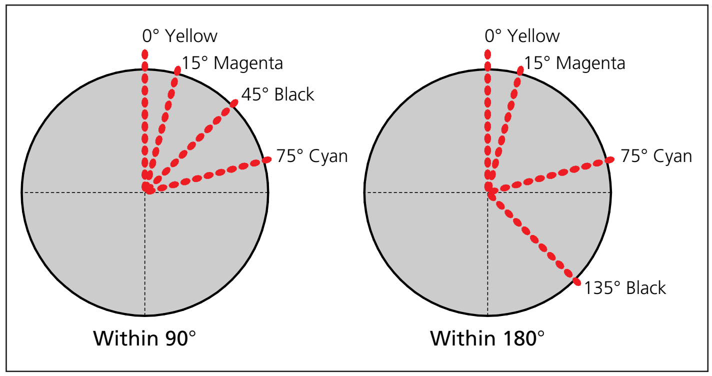
8.9 Avoidance of moiré effects

In film making, suitable angling controls the moiré effect produced between the halftone lines of the individual component colors.

Halftone angling is often given in two different ways:

– within 90° for rulings with two axes of symmetry (e.g. checkerboard and dot rulings)
– within 180° for rulings with one axis of symmetry (e.g. bead ruling)

Example:



Strong colors like CYAN, MAGENTA and BLACK must always be at an angle of 30° from each other. This minimizes visible moiré patterns due to the interplay of the raster rulings. YELLOW, being a weaker color, can be set at a 15° angle from a darker color. In raster printing, yellow should be on the vertical axis of the image, since a moiré caused by the stencil mesh is barely visiable.

Angling of 4-color halftone rulings

Images with a high black content (deep tones)

	Within 90°	Within 180°
YELLOW	0 °	0 °
MAGENTA	15 °	15 °
CYAN	75 °	75 °
BLACK	45 °	135 °

Images where YELLOW + MAGENTA are predominate, e.g. skin tones, orange tones

	Within 90°	Within 180°
YELLOW	0 °	0 °
MAGENTA	45 °	135 °
CYAN	75 °	75 °
BLACK	15 °	15 °

Images where YELLOW + CYAN predominate, e.g. green and turquoise tones

	Within 90°	Within 180°
YELLOW	0 °	0 °
MAGENTA	15 °	75 °
CYAN	45 °	135 °
BLACK	75 °	15 °

General suggestions:

The strongest, most dominant colors should be at 45° in the 90° disposition or at 135° in the 180° disposition (45° left).

For five, six or more colors, the angling should be chosen in such a way that the light colors coincide with their complementary colors, e.g. dark red and light blue, dark blue and light red. An additional grey plate should be angled in such a manner that it does not coincide with colors strongly related to grey.

Angling of 3-color halftone rulings

	Within 90°	Within 180°	
Dark color	45 °	a) 45 °	b) 135 °
Light color	15 °	105 °	75 °
Third color	75 °	165 °	15 °

Angling of 2-color halftone rulings

	Within 90°	Within 180°	
Dark color	45 °	a) 45 °	b) 135 °
Light color	75 °	105 °	75 °

Angling of single color halftone rulings

Within 90°	Within 180°
45 °	a) 45 °

Moiré between the film and the mesh

In raster printing, an additional moiré effect can result from unsuitable angling of the halftone lines of a particular component color in relation to the mesh. This effect is most plainly visible in monochrome prints, whereas multi-color printing tends to conceal it. The moiré effect is most apparent in the 40–60% range.

The moiré can be wholly or partially eliminated in the following ways:

1. By the type of stencil:

   The moiré effect is less apparent with an indirect stencil, since the influence of the mesh is less pronounced than in the case of direct stencils.

2. By the fineness of the mesh:

   The finer the mesh in relation to the raster ruling, the less visible is the moiré effect.

   Recommended ratio between mesh count and the fineness of the halftone ruling:

Mesh count/inch	:	Halftone L/inch
2.50	:	1.00
3.75	:	1.00
5.00	:	1.00

   Examples:

mesh	Ratio	Halftone L/inch
Pecap LE 7-355-31:	2.50 : 1	142 lines/inch
	3.75 : 1	95 lines/inch
	5.00 : 1	71 lines/inch

   i.e. the mesh number is divided by the ratio.

   If these recommendations are followed, there will be hardly any visible moiré effect at halftone angles of 15°, 45° and 75°. In the rare event of moiré still appearing, it is advisable to increase or decrease the number of halftone dots/inch by one or two:

either	0.5-2 halftone dots more
or	0.5-2 halftone dots less.

3. By the mesh angling:

   a) An ideal, universal angle for the mesh on the halftone printing frame lies between 4° and 9°, provided the halftone lines of the component colors, as in the previous examples, are aligned with the vertical or horizontal axis.

Angling the mesh, e.g. to 7.5°, has the additional advantage that the cause of striped print appearance can be traced with certainty to the mesh, or a poorly ground squeegee blade.

Stretching at a certain angle can be ordered from your stretching service. A well-equipped stretching service can provide an evenly straight stretched frame, which is essential for avoiding moiré.

b) It is difficult to load a frame into an automatic printing machine at anything other than right angles. Therefore, it is advised not to angle the image on the stencil, and feed the printing stock at a corresponding angle.

c) There remains the angling of the whole set of film positives (e.g. +7.5°) with respect to the image axis.

4. By the type of halftone raster

a) According to current theory, grained raster, line raster and circular are only suitable for monochrome printing. There is little danger of moiré with these types of halftones. For a line raster, the mesh is angled.

b) Halftones with elliptical dots (bead ruling) can, under certain circumstances, lessen the chance for moiré development. It is for this reason that they are selected to soften abrupt color-tone transitions.

8.10 General recommendations

– A basic requirement for perfect image reproduction is the quality of the film positive, with complete opaque half-tone dots.
– The color separations and the printing inks should follow the same color scale, e.g. EUROSCALA.
– Place the halftone positive on a glass plate, illuminated from below. Place the stretched halftone on the positive, parallel to the image axis. If a moiré appears, turn the film left or right until the moiré effect disappears (approx. 7° is sufficient in most cases).
– The critical zones for the formation of moiré lie in the direction of the threads and their cross-overs.
– Dominant or darker colors tend to cause more moiré problems.
– For 4-color prints, stable metal frames of the same dimensions should be used.

– All frames are stretched with the same mesh.
– Use a dyed mesh for direct stencils.
– Stretch the mesh tightly along the directions of the threads.
– Stretch all 4 frames with the same tension and procedure.
– A perfectly ground squeegee is crucial to a high quality print.
– The squeegee blade should be of about 70° shore hardness.
– The squeegee should be set at an angle of 75°. If the squeegee is set at too flat an angle, it tends to smudge. Set it too steep, or there is a greater risk of mesh distortion.
– The flood bar should not be set too low. The stroke should leave a thin film of ink on the stencil. If the doctor blade is set too low, the stencil becomes overfilled with ink and the print is smudged.
– Halftone images are printed with high-viscosity inks.
– Initial halftone printing trials should be carried out with coarse raster rulings.
– The finest mesh counts require relatively high color pigmentation.
– UV inks tend to smudge, but do not dry in the mesh. For this reason, the halftone film should have a tone value range of 5–80%.
– In 4-color process printing using UV inks, ensure that the additional stencil thickness and the Rz value are no higher than 5 µm.
– To control UV ink smearing when overprinting colors, the following color printing sequence may be used:
  CYAN – MAGENTA – YELLOW – BLACK
– For UV inks, the squeegee should have 75° shore hardness, i.e. generally somewhat harder than with conventional inks.
– The squeegee angle should be approximately 75°.

Recommended halftone line ruling (inches) in relation to mesh count (inch)

The following basic parameters must be established before making use of the recommendation:

a) Type of printing job
b) Type of ink
c) Fineness of halftone ruling

Graphical work, CDs:

Ink type	Halftone lpi	Mesh threads/inch	Thread diameter
Solvent-based inks	up to 120 dots/inch	305 - 420	27, 31 and 34 µm
UV inks	up to 150 dots/inch up to 38 dots/inch	355 - 460 230/2	27, 31 and 34 µm 34 µm
Water-based inks	up to 120 dots/inch	355 - 460	27 and 31 µm

Direct printing onto ceramics:

Ink type	Halftone lpi	Mesh threads/inch	Thread diameter
Water-based inks Floor tiles	up to 60 dots/inch	103 - 195	80, 70, 64, 55 and 48 µm
Solvent/water based inks Wall tiles	up to 90 dots/inch	305 - 355	34 and (31) µm

Ceramic transfers:

Ink type	Halftone lpi	Mesh threads/inch	Thread diameter
Solvent-based inks	up to120 dots/inch	305 - 355	31 and 27 µm

T-Shirt printing:

Ink type	Halftone lpi	Mesh threads/inch	Thread diameter
Pigment ink	up to 60 dots/inch	156 - 195 230	64, 55 and 48µm 40 µm
Plastisol ink	up to 90 dots/inch	230 - 355	48, 40, 34 and (31) µm

8.11 Improved printing stability through achromatic reproduction

Helmut Acker, Production Manager in an electronic prepress house

Helmut Acker writes about achromatic reproduction from the repro house's point of view.

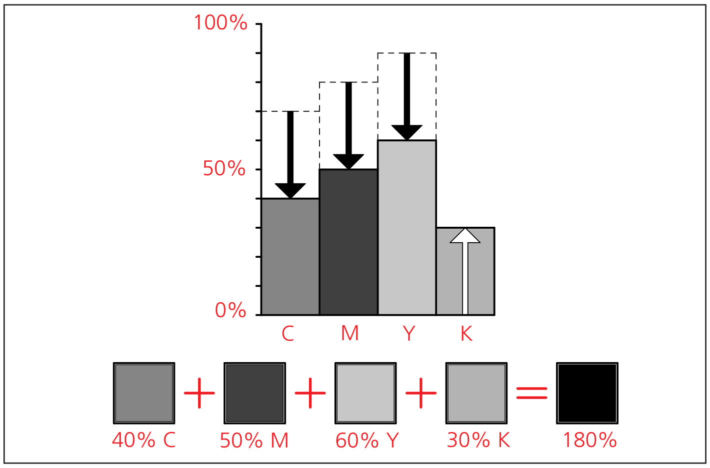
Regardless of the printing process used, multi-color reproductions, where the various hues are produced by rastering, now tend to originate on scanning equipment. Specialized raster types, and rulings, dot shapes and raster angles are either built-in, or are available from dealers as plug-ins.

Modern, customisable color scanners facilitate color separations based either on traditional chromatic techniques, or newer achromatic methods. Given the right software, achromatic films can be produced which are just as reliable and accurate as traditional three-color separations.

There are wide differences of professional opinion about the production of achromatic separations. Some authorities maintain that grayscales should be achieved using black alone, and all composite colors obtained from two process colors plus black. This offers the prospect of saving on expensive process colors, while improving or even matching the brilliance of deep colors – a result much sought-after by offset printers.

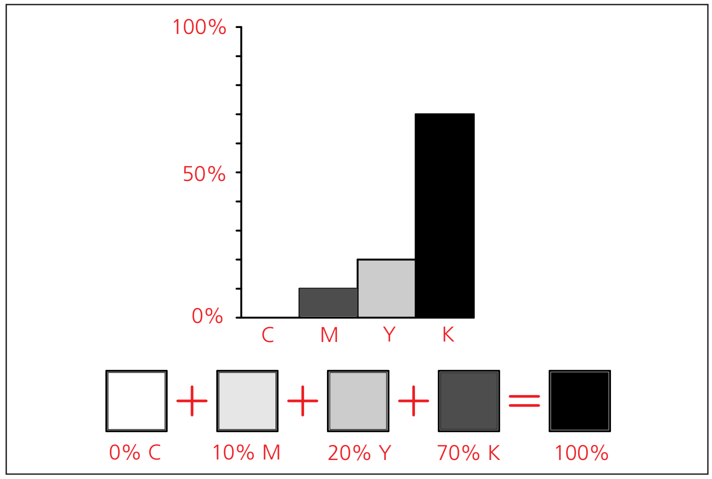
A technical discussion of achromatic films must distinguish between achromatic in a narrower sense, and increased UCR (under-color removal). Practical experience shows that repro specialists must adopt a very different approach to UCR. For technical illustrations of objects like radios, televisions, cameras, binoculars etc, UCR together with a corresponding combination of full black is very successful in reducing coverage from at least 280% to approximately 200%. This gives a more brilliant result, while avoiding color interference effects in areas of dark red or green tones.

On the other hand, illustrations of predominantly full-colored, dark subjects should be given only minimal UCR, to counter the risk of being unable to use black to compensate for strong color removal. This is mainly a problem in gravure and offset printing.



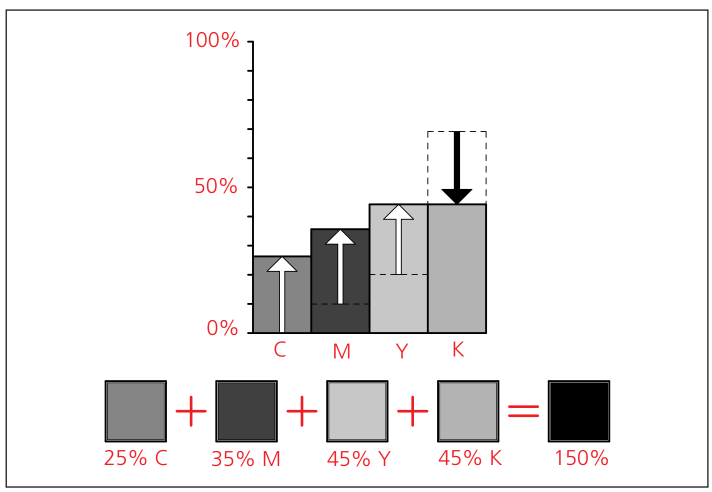
Process color buildup with under-color reduction

In our experience of making software-generated achromatic separations, we generally assemble the separation from cyan, yellow, magenta, and a skeletal black mainly for enhancing the dark tones. We also remove any trace of impure composite color and replace it with black. This results in color separations with much reduced color saturation and an unusually rich black. For example as a result, brown tones no longer contain cyan, while green to olive contains no red. The missing color is always replaced by black. This brings great advantages during the print run. The image generally gains in brilliance, and we notice time and time again: achromatic is more colorful!



Achromatic buildup

Experience shows that, while technically possible, it is inadvisable to carry removal of the third process color to extremes. We know that a grey made up of process colors is more pleasant visually than a half-tone black. We therefore recommend not completely removing the third process color in impure colors, in order to retain a harmonious effect. This technique is known as achromatic buildup with process addition.



Achromatic buildup with process addition

It is fair to ask the reason for discussing achromatic buildup in a raster printing context. It is an established fact that achromatic films offer particular economic and qualitative advantages to offset printers working with four-color and web offset machines. The same can be said of gravure, where offset films are used. Initial results with raster printing indicate that this process stands to gain most of all from achromatic techniques. The missing process color in the final result accelerates drying considerably. The reduction in the amount of ink overprinting virtually eliminates velvet effects. Reduced ink usage brings its own set of advantages. Register problems are much less visible, since black is the only detail-printing color.

Given that on-raster assessment of the color separation is not yet perfect, proof prints remain essential. This inevitably leads to higher film production costs. Extreme use of achromatic technique exacts a price in side-effects and artefacts which have to be taken into consideration. Complete removal the third process color can make certain tones appear harsh, the absence of certain dots in the color rosettes may even lead to moiré, and the smallest differences of register can cause white flashes on some print run specimens. All these aspects, in particular the degree of color removal, must be given due attention by the repro specialist making the color separations.

8.12 Fake color reproduction for textile printing

Heuristic rastering is a digital coloration and design system in which the desired color tones are produced by overlaping textile printing inks on the fibers themselves. A precision-calculated raster doses the individual color elements. A combination of specialised litho work, precision stencil production, and a fine-tuned printing process deposits successive individual ink doses on the mesh fibers, where they subsequently blend together. Four stencils suffice to print a design with a virtually unlimited range of colors . This technique is suitable to producing attractive, multi-colored designs at low cost, with minimal environmental impact.

History of halftone textile printing

There was a time when the printer, as well as the colorist, were artisans if not indeed artists. The requirements were primarily aesthetic, and technical resources were limited.

Times change. It was no longer considered acceptable for the printing machine to limit the maximum number of colors on a printed fabric. Various halftone techniques were developed, including halftone rasters. One well-known example is the "DIRACOP" process, which uses a kind of corn raster. Even now, suitable color separations are prepared by hand, using transparent foils with a grained surface to achieve the half-tone structure.

The corn raster is produced photographically using a magenta contact raster.

There have been repeated attempts at introducing standardised 4-color halftone techniques to the textile printing industry.

Incentives for developing fake color films

The driving forces behind the development of fake color techniques are:

- ability to realize attractive designs
- improved economic factors
- reduced environmental impact

Fake color halftone printing can emulate the appearance of the following techniques:

- halftone
- gradation
- overlay
- multi-color halftone print
- combinations of the above techniques

The basic principles of *fake* color printing can also be found in:

– offset printing
– ink-jet printing
– screen printing

Principles of various printing techniques

The basic principles of the following printing techniques are summarized here, to aid understanding:

– traditional stencil printing
– standardized 4-color halftone printing
– heuristic multi-color halftone printing

Traditional stencil printing

In traditional textile printing, the design is separated into its individual colors. A separation film is used to make a stencil for each color. Areas of the stencil are either permeable or impermeable to ink. These areas may also be occupied in whole or part by various halftone rasters, with due attention to color overlays and underlays. The choice of mesh depends on the textile material to be printed, and is a factor in determining the amount of ink-paste to apply. Ink-paste is pre-mixed to the right color and pressed through the stencil onto the appropriate places on the textile. The maximum number of colors allowed in a design is governed by the size of the printing machine.

Standardized 4-color halftone printing

This technique is similar to graphic raster printing in that the design is separated into primary colors: cyan, magenta, yellow and black. The color parameters used in separation originate from a standard color scale (e.g. EUROSCALA). The color separations are used for graphic raster printing.

Recreating an original design using textile dyes is very difficult, needs much experience, and involves a large number of tests and proof prints. One must be prepared to compromise in matters of color rendition. A restricted color space and color elements produces dull, over-saturated designs. Over printing of the basic colors is usually unavoidable, and the results are unsatisfactory.

***Fake* multi-color halftone printing (Ciba Specialty Chemicals)**

In this technique, the first step is to digitize the design. The chosen raster ruling defines the number of lines/inch, as well as the resolution of the final print. This should take account of the characteristics of the textile stock to be printed, the expected viewing distance, and the desired visual effects.

The dot size controls the brightness (ink quantity) for every single color component. The dots are calculated from tone value scales specific to a given substrate and set of printing conditions. The fake color calculated dots are recorded on film (halftone separation)

The films are used to make printing forms, which reintegrate the individual component dots to reproduce the original design. Correctly sized dots, correctly located, at a calculated angle, on a suitable textile substrate and with the correct inks and concentrations, combine to reproduce the form and color of the original design.

Let us examine the build-up characteristics of inks used in traditional textile printing. Ink build-up is responsible for generating a visually perceptible printed color depth that is related to the ink-paste concentration. It is also a characteristic of the ink. The way in which the inks build up is affected by the following factors:

– the substrate
– pre-treatment
– ink- composition
– ink- volume

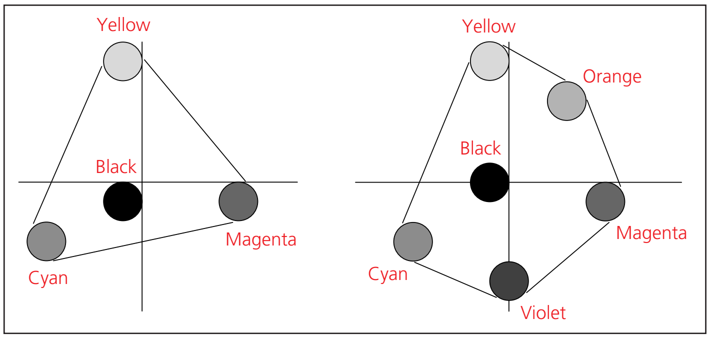
With *fake* color halftone printing, the tone value behavior of various raster values is similarly analysed under given production circumstances. The halftone value describes the proportional size of a dot relative to 100% (maximum) coverage. The tone value behavior on the textile substrate describes the color combination (visual color depth) as a function of percentage coverage (halftone dot size).

The tone value characteristic is fundamental to fake color halftone printing, and deserves a corresponding amount of attention.

Unlike traditional printing, the heuristic method varies the ink-paste concentration. This gives the fully-saturated color at 100% solid area, while a 1% tone value gives the smallest possible addition to the overall color mix.

The tone value characteristic, coupled with a suitable choice of inks, determines the achievable color space.

In heuristic multi-color halftone printing, the color space is not bound to a fixed number of inks. The original design may contain colors that lie outside the space that is printable using 4 colors. To reproduce a brilliant blue, for example, requires an extra blue ink. It is the same in the orange area, where an orange ink is necessary. Taken to the other extreme, there are designs with a color space that requires just 3 inks.



Example of multi-color halftone printing

Color values are first defined, then described in terms of corresponding raster ruling. Separations are then made, based on the textile inks specifically chosen for the job. The basis is the calculated tone value / raster ruling, taking all contributory factors into account (type, raster, angle, mesh, printing sequence, etc.). Production factors are recorded during process analysis, and required degree of reproducibility is achieved through optimisation and standardisation of the individual steps in the process.

The raster films are adjusted to the entire gravure technique (specially selected mesh), technical printing data, color influences and characteristics of the lithographic material. The resulting stencils, used in correct sequence with the defined ink colors and concentrations, give accurate color rendition of the original design on a given textile substrate.

8.13 Objectives of heuristic halftone printing

– more attactive designs
– cost/economic factors
– environmental considerations

More attractive designs

The Ciba multi-color technique with 100 brightness levels allows a theoretical palette of 4 million reproducible colors.

These can be printed using 4 screen. Textile printers can achieve soft color gradations, defined half-tone values, calculated overlays and 3-D effects.

Cost/economic factors

Using this technique, even multi-colored designs require only a minimum number of stencils. This has a strong influence on the overall printing cost.

Given that production printing never requires more than a few stencils, the number of personnel operating the printing machine can also be reduced. Setup times for printing a new design are shorter, since there are fewer stencils to change and the printing inks are the same for all designs, meaning that they do not have to be changed.

Heuristic halftone printing also reduces the workload in the ink mixing shop. It is no longer necessary to calculate ink quantities and mix their individual components. Checks and controls are needed only for the basic colors, which are produced in large quantities with associated economies of scale.

The number of expensive proof prints is minimized. Experience has shown that fake color halftone technique, correctly applied, eliminates the need for corrections and modifications.

Environmental considerations

The problem of processing and recyling old ink does not arise with this technique. Where the same ink-pastes are used for all designs, left-over ink is no longer an issue. Whatever is not consumed one day can be used the next.

Installations like ink scoops, delivery pipework, squeegee systems and ink cisterns no longer need to be cleaned during every design change; instead they can be used straight away for the next one. With traditional methods, clean up wastes approximately 10 kg of ink per stencil. Eliminating this step reduces the demands on the wastewater system.

In halftone printing, the ink-paste deposit depends not on coverage, but the average color density of the design. Lighter shades are achieved through a lower ink-paste deposit. From the fake color designs produced to date (approx. 400), the estimated average color intensity is around 40%. This in turn represents an approximate 60% reduction in liquid effluent from chemicals in the ink-paste (urea, alginate, additives, etc.).

8.14 Technical considerations

This technique requires cooperation between the end user and Ciba. Successful results depend on the quality of cooperation. A heuristic raster based on incorrect data is unusable. It is absolutely essential that the inks specified in the halftone calculation are also deployed in production.

The halftoning mechanism (mixing ink-pastes on the fibres themselves) necessitates transparent pigments. If non-transparent pigments are used, one can expect reproducibility problems within a production batch. Where halftone dots overlap, a non-transparent pigment will obscure the previous ink layer.

9. Printing

The following are recommendations for screen printing manually and on automatic flat bed machines.

Many factors influence the results of the printing process. The most important variables are:

- design and construction of the printing machine: heavy, light, or precision construction
- stability of the printing bed, type of register adjustment, squeegee action, etc.
- type of mesh, especially the quality of printing form / screen tension
- squeegee set-up, i.e. blade hardness, accuracy of the ground edge, pressure, speed and angle
- off contact distance (distance between the stencil and the substrate to be printed)
- peel adjustment (where applicable)
- positional accuracy of the print substrate (register stops, print bed stability)

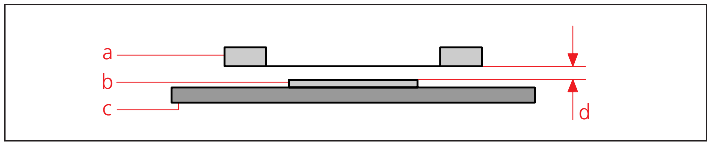
In view of the interplay between all the above factors, it is advisable, where practical, to limit the selection of screen frames to a few standard sizes.

To gain practical printing experience in a systematic manner, certain basic rules should be observed, the two most important being:

- Limit the initial job diversity, i.e. restrict the variety of designs attempted.
- When proofing, alter only one factor at a time – i.e., never attempt to change two or more settings simultaneously.

9.1 Setting up of a flat bed machine

For clean prints with accurate register, correct setting of the off contact and lift-off distances is important.



a) *frame/screen*
b) *substrate*
c) *printing table*
d) *off contact*

"Off contact" is the distance between the screen and the substrate immediately before printing, when the frame is in the lowered position.

The "off contact" distance is necessary to prevent the screen from touching and possibly smearing the substrate before printing, and also to allow the tightly stretched screen to rise clear of the print immediately after the squeegee has passed.

The off contact should be as small as possible, e.g.

– for a DIN A3 screen 1/32 - 1/8 inch

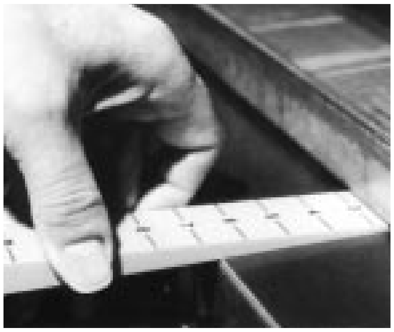
– for a DIN A0 screen 1/2 - 3/16 inch

The off contact is usually slightly greater for manual printing than on machines with mechanical squeegee action.

SEFAR measuring wedge

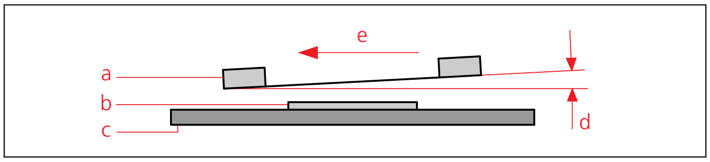
With flat bed printing machines, an even off contact distance is very important for exact register and a perfect print image. If a stencil is not placed perfectly flat in the machine, squeegee pressure is unbalanced because the blade presses down harder on the raised part of the stencil. This results in an uneven, distorted image.

The SEFAR measuring wedge provides a simple means to verify uniform snap distance. Simply slide the wedge under all four edges of the stencil frame and the machine bed in turn, and read the off contact distance in mm. The optimum off contact distance depends on the dimensions of the frame and the printed image, the tension of the mesh, the ink composition, and the desired printing job.



Off contact measuring wedge

In order to improve clearance between the screen and the substrate, many mechanical printing machines incorporate an automatic lift-off mechanism, which raises the screen progressively higher as the squeegee moves forward. The off contact angle behind the squeegee remains constant from start to finish on each print stroke.



a) *screen*
b) *substrate*
c) *printing table*
d) *lift-off*
e) *printing stroke*

The quality of stretch, the snap-off and the lift-off all help to raise the screen mesh from the printing immediately after the squeegee passage. If the screen were to remain in contact with the freshly printed substrate, the slightest shift of substrate or screen would smudge the wet ink.

All three factors are adjustable:

– mesh tension (see the section on stretching)
– off contact distance
– lift-off motion

If any of these is altered, the other two variables must also be adjusted a little to achieve detailed print results.

Excessive off contact and lift-off are detrimental to accurate register.

Reducing the printing speed also helps to reduce the adverse ”drag” effect of the screen on the freshly printed substrate.

On cylinder printing machines, no lift-off is necessary as rotation of the cylinder bed gives the same effect.

9.2 The squeegee

Material

Squeegees for screen printing are made of natural or synthetic rubber (Neoprene), or of polyurethane (Vulkollan, Ulon, etc.).

Those of natural or synthetic rubber wear out faster, but, on the other hand, they are much less prone to accumulating electrostatic charge.

Polyurethane squeegees have better abrasion resistance, but a greater tendency to accumulate electrostatic charge during printing.

Both materials harden with age, and overlong exposure to solvents causes the squeegee to swell, leaving the blade wavy and unusable. Squeegees should therefore be cleaned and dried immediately after printing. The edges and sides of the squeegee should be free of blemishes like pock-marks and scratches, as these tend to give streaky prints. Squeegees should be frequently re-ground: sharp, clean edges are essential to good quality printing.

Hardness

Squeegee hardness is expressed in degrees shore, the generally recommended region being 60° – 75° off contact hardness.

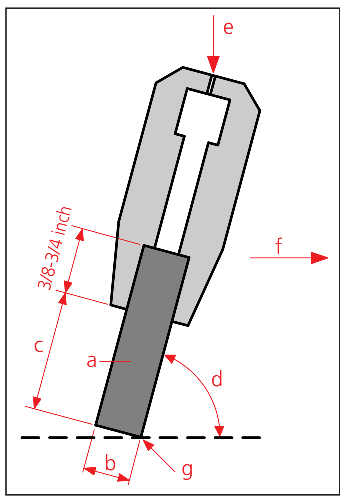
Harder squeegees (70° – 75°off contact) are suitable for large formats and halftone printing.

Softer squeegees (60°– 65° shore) are preferable for solid overall patterns and substrates with an uneven surface.

Excessive squeegee hardness can cause difficulty in maintaining register, due to the high frictional drag with subsequent distortion of the screen mesh. This also tends to reduce the stencil life.

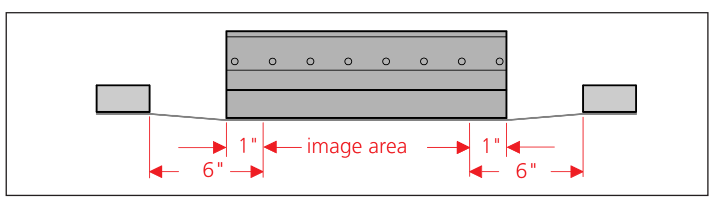
Excessive softness combined with high pressure can cause the squeegee to flex backwards. The resulting squeegee angle becomes too shallow, allowing ink, to be swept over the mesh, is pressed onto an elongated section of the printing substrate. Ink then runs under the stencil.

Dimensions



a) Squeegee hardness
b) Squeegee thickness
c) Squeegee (free) height
d) Squeegee angle
e) Squeegee pressure
f) Squeegee speed
g) Squeegee grinding (profile / surface)

Squeegee profile



Squeegee front view

The dimensions of the printing frame should be such as to leave a clearance of at least 4.5 inches between the inside edge of the frame and each end of the squeegee. Insufficient clearance can result in visible distortion of the printed image.

Squeegee sharpening

The condition of the squeegee blade is important to the production of sharp, clear prints.

A sharp-edged squeegee will precisely control the amount of ink passing through the screen. This is an important factor in the production of fine detailed work and halftones.

A blunted or intentionally rounded squeegee edge fails to skim the ink off the screen in a precisely metered fashion. Instead, it forces an excessive amount through to the substrate, smudging details. However, ink application at such high levels may be desirable to give good coverage, especially in solid areas.

A poorly ground squeegee blade will produce streaky prints; however, this effect can sometimes also be caused by irregularly woven screen mesh. It is often extremely difficult to determine whether the squeegee or the mesh is causing streaky prints. The only certain way is to stretch the screen mesh on the bias (i.e. at an angle to the frame) so that the threads run at an angle to the frame and the printing stroke.

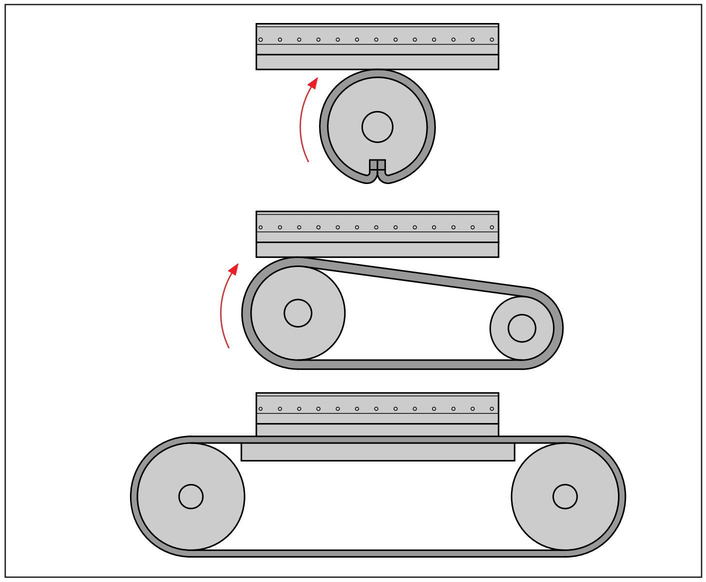
Squeegee streaks are cured by carefully rubbing the cleanly-ground squeegee edge with a polishing cloth.

The squeegee sharpening machine must have a firm clamping device for the squeegee. The blade should be ground parallel to the length, so as to allow accurate sharpening.

Avoid overheating the squeegee during the sharpening process.

Round-off the squeegee ends to prevent a potential sharp corner that may puncture mesh.

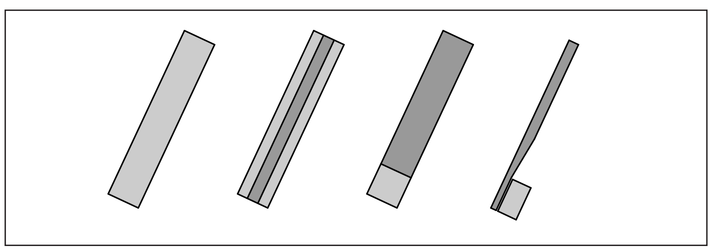
Emery belts are used for squeegee sharpening. Belts may be fitted over single or multiple rollers, as shown in the diagrams below.



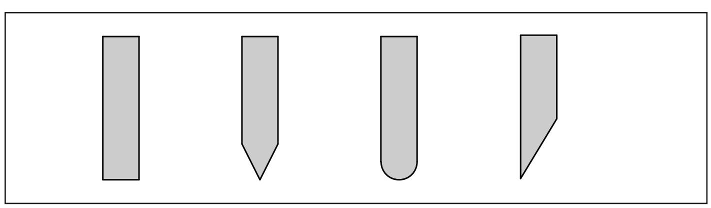
Types of squeegee sharpening machine

The emery belts should be of 80 – 180 grit, depending on the squeegee rubber material and the printing application.

Squeegee sections



Squeegee types

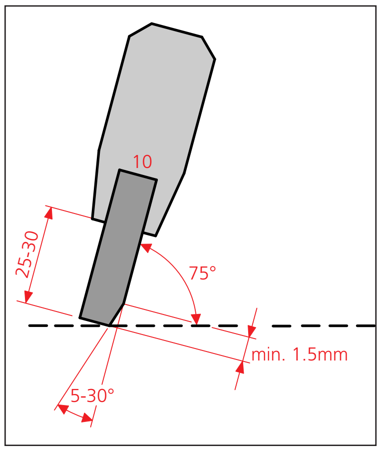


Squeegee edge profiles

Special squeegee sharpening for screen printing on circuit-board tracks of 70 µm or more

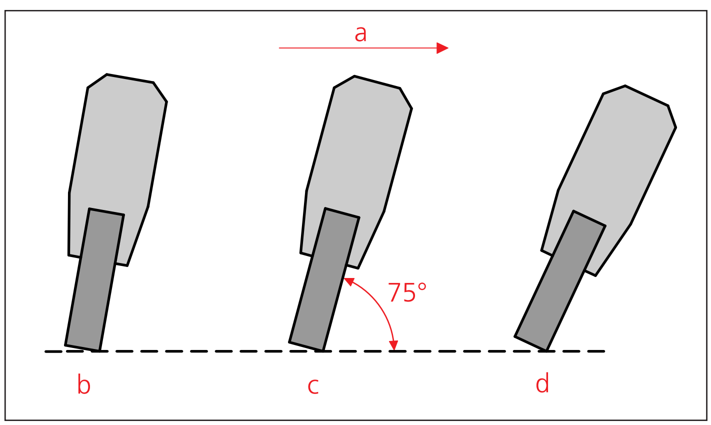
5° – 30° angle-grind at the squeegee edge.

Proof prints are essential. The viscosity of the ink paste has a considerable effect on the result.



Special angle-grinding at the squeegee edge

Squeegee angle



Squeegee angle: a) printing stroke
b) steep angle c) normal angle d) low angle

The optimum squeegee printing angle is 75° from the screen. Large deviations from this angle can adversely affect ink control and accuracy of register.

Steep angle: In this position, the flexibility of the squeegee blade is impaired, increasing friction with the screen mesh. The blade's increased cutting action reduces the ink deposit, while dragging and stretching the mesh, which causes loss of registration.

Low angle: The squeegee blade flexes too far backwards, pressing more ink through the stencil mesh. Ink tends to run under the stencil.

Notes for textile printing:

Rounded squeegee profiles are most commonly used in this application. Depending on the ink absorbency of the printing substrate, squeegee profiles with a suitable radius and corresponding hardness are used.

Squeegee pressure

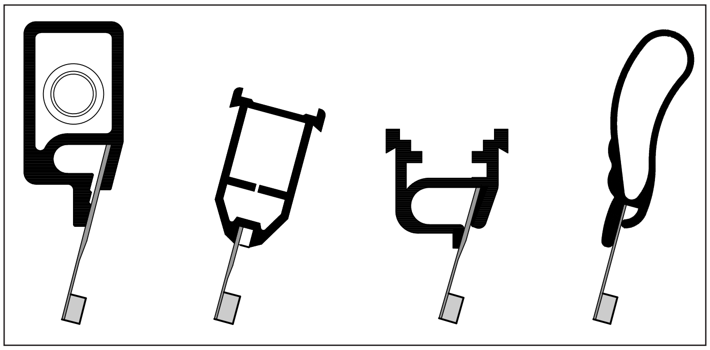
As already stated, excessive pressure adversely affects the accuracy of register, since the squeegee drags the screen mesh in the direction of the stroke. Therefore, pressure should be kept to the minimum necessary for good print results. Pressure adjustments can be made as follows:

– Adjust the squeegee so that it is clear of the screen while in the normal printing position.
– Place the squeegee in the center of the image area, i.e. the center of the print stroke.
– Lower the squeegee until it is just clear of the screen, parallel to the mesh.
– Adjust both set screws to bring the squeegee into contact with the printing substrate.
– Make final adjustments to the squeegee setting during the first trial pulls on setup sheets.

Squeegee pressure must not be altered during the print run, as this can cause color and register changes. In multi-color printing, squeegee pressure should be identical for all screens. Raising the pressure lengthens the printed image, leading to register problems.

The squeegee should be cleaned immediately after printing. Prolonged exposure to solvents impregnates the blade, making it soft and subsequently useless.

RKS squeegee system



Squeegee profiles

Advantages of the RKS system are:

– quick fitting and removal
– constant blade angle
– easy control of squeegee pressure
– low wear

RKS squeegees can also be fitted to conventional squeegee holders.

9.3 Flood bar (Doctor blade)

The flood bar is attached parallel to the print squeegee, but with a lighter pressure. It spreads a thin film of ink on the screen image area which prevents the ink from drying.

It is important that the flood bar or scraper edge is not damaged in any way, with no sharp corners or edges, burrs, etc.

Periodic grinding of the flood bar gives a uniform ink lay on the screen, especially with large formats applications.

9.4 Printing speed

The ink flow or ink transfer through the screen depends on several factors, such as printing speed, ink viscosity, type of squeegee, etc.

When the printing speed is too high in comparison to the other conditions, the mesh openings are not completely loaded with ink. This results in poor prints. Printing speed should always be set in conjunction with other determining factors, for example:

– ink viscosity

– stencil coating thickness.

– mesh with fine mesh openings

– squeegee angle

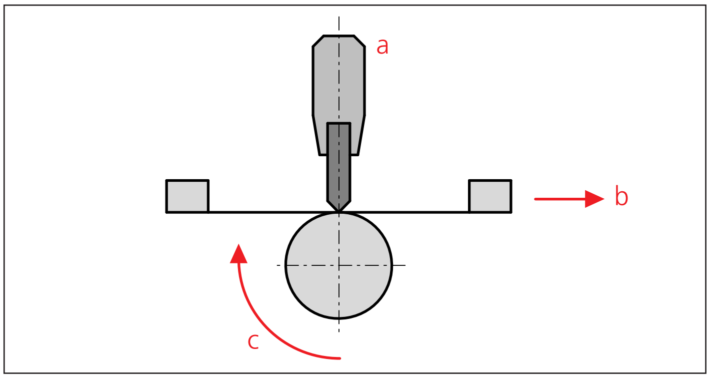
– large areas requiring good ink coverage.

The above variables are not the only relevant factors affecting print quality, but any of the above will necessitate a reduction in print speed.

Changing speed during the print run will result in a corresponding change in the print quality. If printing results are unsatisfactory (smearing, poor register, etc.), one or more of the preceding factors are generally responsible. Keep in mind that when trying to correct any misprints, only one factor at a time should be checked and if necessary, altered. The prime condition for success is a well made screen equal to the requirements of the printing task. (See also other chapters of this handbook.)

9.5 Object printing

This section deals with the printing of shaped objects such as bottles, glassware, crockery, jars, tools, instruments, boxes, sporting goods, machine parts, etc.



a) stationary squeegee
b) movement of screen
c) direction of rotation

Basic concept for printing round objects:

Printing shaped objects needs a more flexible screen to make full contact with the curved surfaces. Polyamide meshes (PA) have the ideal elasticity to allow a perfect fit to various shaped objects and surfaces.

Direct stencils are most frequently used for printing shaped objects, since indirect stencil films are not elastic enough to follow the mesh as it adapts to the shape of the substrate.

It is usually uneconomic to reclaim screens used on long print runs with difficult or abrasive printing substrates. Mounting new mesh is often faster, cheaper and more reliable.

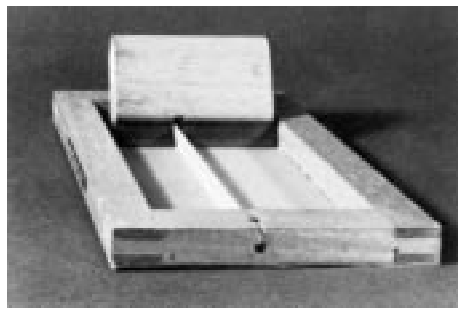
Squeegees for printing round objects are normally cut with an equal bevel, often referred to as ”V” cut or ”double cut” squeegees.

Rectangular squeegee profiles are generally chosen for UV inks, and angled at approximately 75° to the mesh plain.

Recommendations laid down by the manufacturer of the printing machine should be noted.

9.6 Single operation multiple color printing

Partitioning the squeegee and the stencil allows two colors to be printed in the same pass. This is only possible when the respective colors are separated by 1/2 inch or more.



Split stencil for two-color printing

The stencil is partitioned by inserting a divider (cardboard, plastic, or a thin wooden batten), secured and sealed with an adhesive.

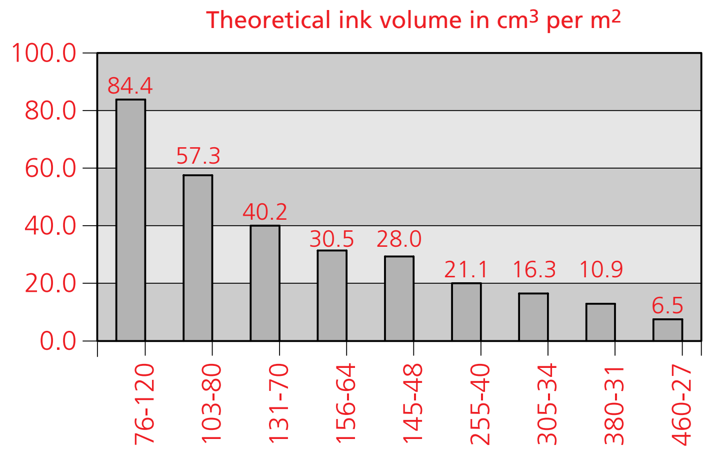
9.7 Ink deposit

The theoretical ink volume of the mesh can be used as a guide for wet ink deposit, as well as being used to calculate ink consumption.

Example:

An ink or paste with 60% solid content, printed with Pecap LE 7-195-48 PW results in a wet ink deposit of 28 cm^3/m^2, which corresponds to a thickness of 28 μm.

During the drying process, the 40% solvent content evaporates. The remaining dry ink deposit is only 17 μm.



Mesh number

Refer to the technical information in the mesh datasheets.

9.8 UV inks

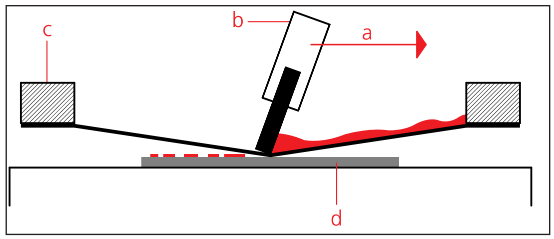
UV inks have a very high solid content, approaching 100%. Extra thin and fine meshs (305-31 – 460-27) are necessary to reduce ink consumption and ink deposit. For extreme ink deposit reduction (UV varnish) we recommend a one side calendered mesh such as SEFAR® Pecap LE UV.

In 4-color halftone printing, care should be taken that the stencil thickness on the mesh does not exceed 3–5 µm.

9.9 Printing systems

Flat bed printing

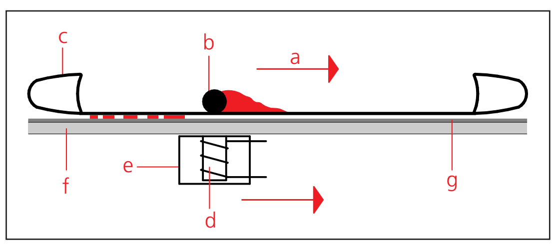
Flat bed screen printing is used for printing both flexible and rigid stock, e.g. paper, cardboard, plastic foils, wooden, plastic or ceramic tiles, textiles, and flat objects.



a = printing direction
b = squeegee
c = printing frame
d = substrate

Special technique for industrial textile printing

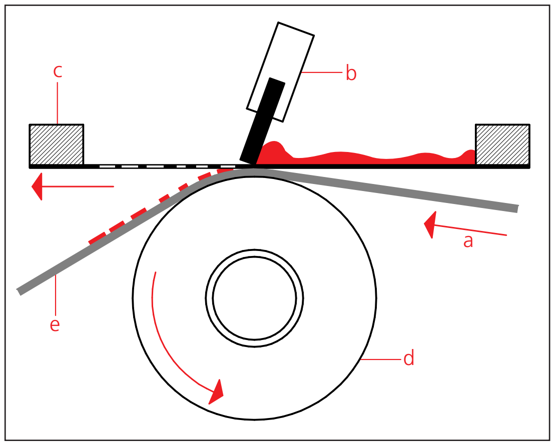
In this application the squeegee is a circular steel rod. Ink quantity is controlled by the squeegee diameter and the magnetic force exerted from below the printing machine bed. The stencil is in contact with the substrate.



a = printing direction
b = squeegee
c = printing frame
d = magnet
e = magnet carriage
f = rubber mat
g = substrate

Cylinder bed printing

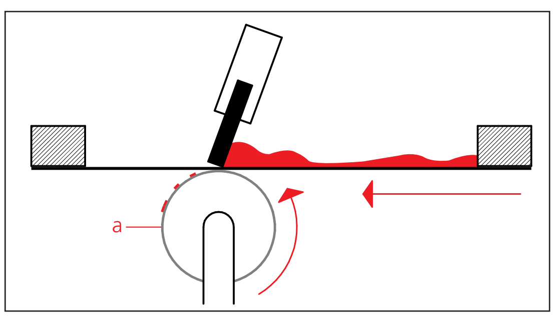
Cylinder bed machines are suitable only for flexible print stock like paper, plastic foils, etc.



a = printing direction
b = squeegee
c = printing frame
d = back pressure cylinder
e = substrate

Printing on cylindrical objects

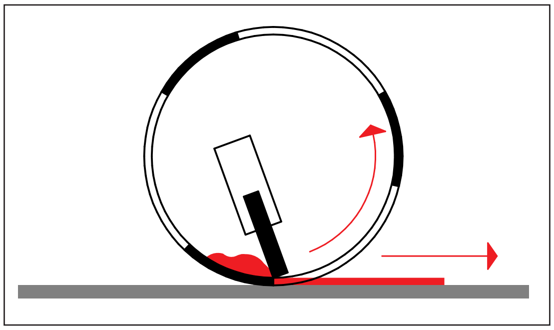
These machines use the substrate itself as the back pressure cylinder, e.g. bottles, tubes, jars, etc.



a = substrate

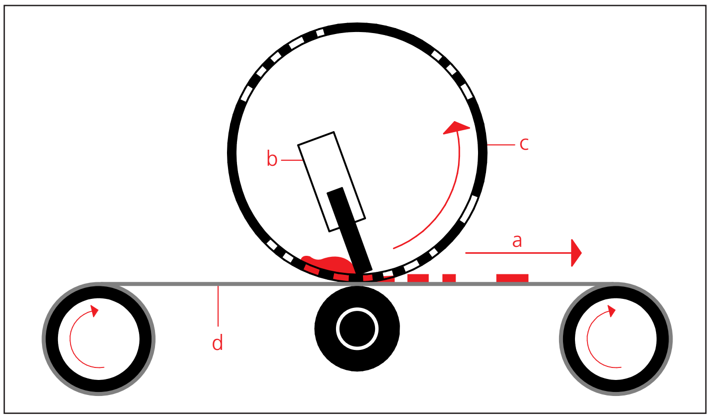
Rotary printing (single substrates)

Example: Ceramic tile printing



Rotary printing (reel to reel)

Printing occurs continuously, either from a feed to a take-up reel, or on a flat substrate fed by conveyor belt under the rotating cylinder (paper, foils, textiles, ceramic tiles, etc.).

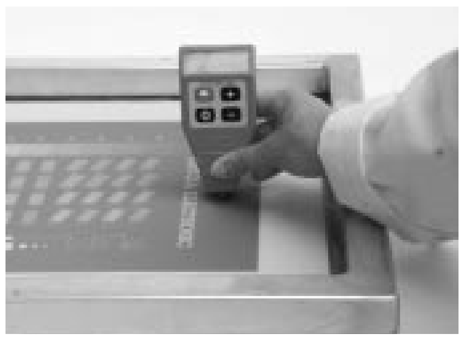


a = print direction
b = squeegee
c = cylindrical stencil
d = substrate (on reels or conveyor belt)

10. Measuring instruments

Consistently high printing quality can only be achieved and maintained through the use of internal standards. These in turn demand reproducible data and tolerances, which can only be gathered using suitable measuring instruments.

10.1 Coating thickness



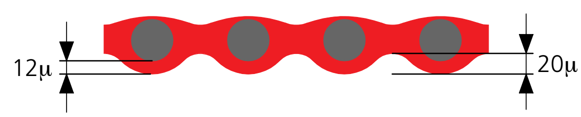
This instrument measures the stencil coating thickness on the mesh. The thickness on the mesh determines edge sharpness, resolution, and the wet thickness of the ink deposit on the printing substrate.

10.2 Roughness

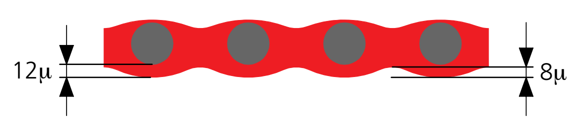
This instrument is used to check the stencil surface. The measuring probe is simply placed on the surface to be measured at an angle of 22.5° to the mesh threads. During the measuring sequence, the probe moves a few millimetres in order to take a predetermined number of measurement samples at the highest and lowest points on the surface. The measured average in µm appears on the instrument's digital display. A perfectly flat surface would show a value of 0.

The Rz value (DIN nomenclature for average roughness) for screen printing stencils should typically be less than the measured coating thickness. Proper Rz is dependent on the requirements of the individual print job. A relatively smooth stencil surface is essential to printing sharp edges and avoiding saw-tooth effects.

Poor: Rz > coating thickness



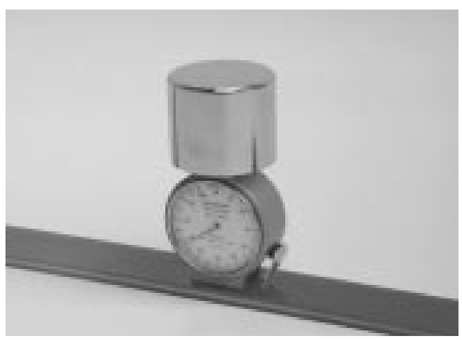
Good: Rz < coating thickness



10.3 Radiometer (incident radiant energy measurement)

Stencils cure and harden best when exposed to a good light source. The source should radiate predominantly in the UV range between 350 – 420 nm. Lamps have a limited life and the radiant energy falls off as the lamp ages, typically requiring longer exposure. A radiometer provides the simplest means for measuring lamp efficiency.

10.4 Hardness meter (Shore measuring instrument)



This instrument is used to check the hardness of the squeegee rubber. The rubber is affected by various solvents and is also subject to a natural ageing process that causes the hardness to change over time. Every color pass in a printing job should use the same squeegee size and hardness. Different squeegees lead to register problems and color shifts.

10.5 Viscosimeter

The viscosity of the printing medium (ink, lacquer, paste, etc.) has a strong influence on the attainable printing speed, amount of ink passing through the stencil, wet film thickness, edge sharpness, etc. For consistently reproducible printing results, the viscosity of the printing medium must be as constant as possible.

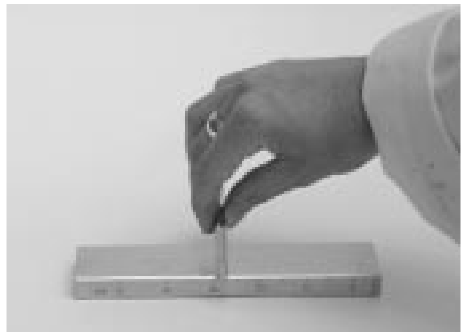
A viscosimeter is used either to measure printing medium viscosity, or adjust the viscosity to a predetermined value. Printing medium viscosity is usually measured in Pascal or Poises.

10.6 Wet coat thickness

Certain screen printing applications require carefully controlled and reproducible coating thickness. The solution is this simple device for measuring the thickness of the wet ink deposit.

The instrument is rolled carefully over the freshly printed surface. The coat thickness in µm is then read off the scale at the point where the ink deposit ceases.

10.7 Grindometer for measuring particle size



The particle size of the printing medium must be at least 3x less than the mesh opening of the screen printing mesh. A test sample is simply smeared over the grindometer. The particle size in µm is read off the scale at the point where the smear ends.

10.8 Recording thermometer/hygrometer

Printing media, printing stock and printing frames are all strongly affected by temperature and atmospheric humidity. Monitoring air quality in the screen, draft print press room can avoid many problems, or help pinpoint their cause.

11. Recommended choice of mesh

Application, sector	Polyester mesh Pecap LE		Polyester mesh Pecap LE		Polyamide mesh PA 1000**	
	Conventional inks		UV inks ***		Conventional inks	
	from	to	from	to	from	to
Graphical printing						
Line artwork	230-40*	305-34*	355-34*	420-31*		
Lacquer overprinting	230-40	305-34	355-34	460-31		
Halftone screens up to 70 lpi	305-34* 305-31*	380-34* 380-31*	355-34*	460-27*		
Halftone screens from 70 lpi to 133 lpi	380-34* 355-31* 380-27*	 420-31* 420-27*	380-34* 420-31*	380-31* 460-27*		
Printed circuit boards						
Overlay solder mask	30-140	45-250				
Photosensitive solder mask	60-120	175-55				
SMT solder paste	83-70					
2-component solder mask: Conductor thickness 35 µ 70 µ	 175-55* 110-80*	 195-48* 137-64*				
UV solder mask			175-55*	195-48*		
Carbon conductive lacquer	92-90	175-55				
Etch resist	230-48*	305-34*	305-34*	355-34*		
Plating resist	230-48*	305-34*	305-34*			
Marking print	305-34*	355-31*	355-34*	380-31*		
Membrane keyboards						
Insulation lacquer	92-100	175-55				
Silver conductive paste	123-70*	175-55*				
Adhesive	123-70	195-48				
UV structural lacquer			195-48	420-31		
Decor foil	230-48*	305-34*				
Transparent windows	305-34					

*) for fine lines and halftone rulings: dyed mesh
**) for large print runs: PA 2000 (range is being expanded)
***) for minimal ink deposit: calendered mesh Pecap LE UV

Continued

Continued

Application, sector	Polyester mesh Pecap LE Conventional inks from	 to	Polyester mesh Pecap LE UV inks *** from	 to	Polyamide mesh PA 1000** Conventional inks from	 to
Designs, T-shirts						
Glitter	25-260	60-120				
Flock adhesive	45-180	123 -70				
Puff-up colors	54-140	123 -70				
Overprint	83-100	103 -80				
Pigment ink printing, areas/lines	103-80	175-64				
Plastisol transfer	123-80	305-34*				
Universal fabric	123-55					
Plastisol direct	137-64*	305-34*				
Pigment inks, half-tone	156-64*	255-40*				
Sublimation transfer	195-48*	305-34*				
Textiles, flat films						
Heavy décor fabrics (terry cloth, denim)	45-180	123-70				
Smooth, dense fabrics (table cloths, heavy curtain material)	110-80	137-64				
Smooth, light fabrics (scarves, light curtain material)	137-64	195-48				
Light, porous material (especially detailed effects)	195-48	305-34				
Ceramics						
Glaze printing, coarse, embossed effect	13-450	54-140			25-350	60-160
Covercoat	30-140	83-100				
Glaze printing, medium to fine	54-140	156 -64			60-160	156-60
In and under-glaze (direct printing)	110 -80	255-40*			110-90	255-38*
Superimposed / decals:						
Areas/lines	195-48*	380-31*			195-50*	380-30*
Fine lines / half-tone	255-40*	420-27*			255-35*	420-30*
Gold and lustre inks	305-34*	420-31*			305-35*	460-30*

*) for fine lines and halftone rulings: dyed mesh
**) for large print runs: PA 2000 (range is being expanded)
***) for minimal ink deposit: calendered mesh Pecap LE UV

Continued

Continued

Application, sector	Polyester mesh Pecap LE Conventional inks from	to	Polyester mesh Pecap LE UV inks *** from	to	Polyamide mesh PA 1000** Conventional inks from	to
Glass						
Automotive glass:						
Black surrounds for wind-						
screens, rear and side windows	137-64*	195-48*				
Antennas	195-48*	255-40*				
Silver paste (heated windows)	195-48*	255-40*				
Sun-roofs	255-40*	305-34*				
Constructional glass:						
Curtain windows, doors,						
windows, shower-cabins,	76-120	195-48*				
Mirrors	195-48*	305-34*				
Cosmetic bottles:						
Inks					195-50*	305-35*
Precious metals					305-35*	380-30*
Pharmaceuticals:						
Laboratory glassware, bottles					195-50*	305-35*
Ampoules					305-35*	355-30*
Beverages:						
Bottles, glasses					137-60	305-35*
Household durables:						
Fascias for washing						
machines and ovens						
(Masks)	110-80	175-55				
(Lines and halftones)	195-48*	255-40*				
Lampshades, table tops,						
furniture	137-64	255-40*				
Amusement machines:						
Front and side panels	195-48*	305-34*				
Souvenirs:						
Herald pictures	137-64	255-40*				
Advertising:						
Hotel, restaurant and						
shop signs	110-80	195-48*				
Objects (plastics, etc.)						
Opaque areas	255-40*	305-34*	355-34*	380-31*	255-38*	380-35*•
Halftone and fine lines	305-34*	420-27*	380-31*	460-27*	305-35*	460-30*•

•) UV inks: PW = 1:1 only