SAATI PRINT™

HANDBOOK

Tech Tips for Screen Printers

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Published by SaatiPrint U.S.A.

Welcome to the SaatiPrint Tech Tips handbook, which we hope will become a valuable reference to help you achieve better results for your customers. We have separated the Tech Tips from the SaatiPrint catalog in an attempt to make the information more portable and user-friendly, and to ensure that they can be independently updated and reprinted to remain as current as possible.

SaatiPrint North America was officially formed last year following the acquisition of the E.W. Dorn Company by the Saati Americas Majestech Division. SaatiPrint is the only manufacturer of both high precision woven screen-printing mesh and complementary chemicals. These leadership products are further enhanced by a full portfolio of pre-press equipment and supplies, developed together with our supplier partners to meet the diverse screen making needs defined within each of the major screen-printing market segments including Graphics, Electronics, Textile, Optical Disc, Glass and Ceramic.

In addition to this Tech Tips handbook and the catalog, we have launched a new global web site www.saati.com, published a new Fundamentals of Screen Printing book written by Andre Peyskens, and invested in a SaatiChem e-commerce web site to make it easier to purchase gallons of emulsion www.emulsionstore.com.

It is our intention to continue to reach out and find more ways to communicate with our customers, which will drive continuous improvements in our products, process and services. Please contact us with any suggestions, which will help us to improve, and/or for personal attention to your technical problems or product needs. Thank you in advance for your help.

SAATI PRINT™

SaatiPrint North America

Screen printing is our passion, but our goal is customer satisfaction.

CONTENTS

The Tech Tips, directions, recommendations and specification charts contained in this brochure are meant as guides to the use of the products and shall not bind the company. Product specifications are subject to change without notice. Complete product directions and Material Safety Data Sheets are available by dialing our toll-free number. (MSDS sheets are shipped routinely with every shipment of any products containing hazardous ingredients.)

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Fabric Selections

Fabric Selection Chart

APPLICATION	FABRIC	MESH COUNT RANGE				
		inch	(cm)		inch	(cm)
GRAPHICS						
Poster (UV Inks)	Saatilene Hitech	380	(150)	—	460	(180)
Poster (Solvent Based Inks)	Saatilene Hitech	305	(120)	—	420	(165)
Stickers/Self-Adhesive	Saatilene Hitech	305	(120)	—	420	(165)
Bottles, Containers, Misc. Objects,	Saatilene Hitech	230	(90)	—	460	(180)
Promotional Items	Saatilene Hibond	230	(90)	—	460	(180)
	Saatilon	305	(120)	—	460	(180)
Touch Panel Printing	Saatilene Hitech	255	(100)	—	380	(150)
(Polyester/Polycarbonate)						
Front Panel Printing	Saatilene Hitech	255	(100)	—	380	(150)
Credit/Account Cards – Graphics	Saatilene Hitech	305	(120)	—	380	(150)
Decal – Graphic	Saatilene Hibond	230	(90)	—	460	(180)
Wood Decoration	Saatilene Hibond	196	(77)	—	330	(130)
TEXTILE						
Water-Based Inks	Saatilene Hitech	86	(34)	—	230	(90)
Flock Printing	Saatilene Hitech	41	(16)	—	110	(43)
Glitter Inks	Saatilene Hitech	24	(9,5)	—	86	(29)
Puff Inks	Saatilene Hitech	30	(12)	—	140	(55)
Plastisol Inks	Saatilene Hitech	110	(43)	—	355	(140)
Transfer Printing Sublimatic	Saatilene Hitech	305	(120)	—	380	(150)
Transfer Base	Saatilene Hitech	110	(34)	—	158	(62)
Carpet Decoration	Saatilene Hitech	61	(24)	—	74	(29)
ELECTRONICS						
"Etch" Resist Primary Image	Saatilene Hitech	255	(100)	—	305	(120)
"Plating" Primary Image	Saatilene Hitech	305	(120)	—	355	(140)
"Solder Mask" – Solvent	Saatilene Hitech	125	(49)	—	196	(77)
"Solder Mask" – UV	Saatilene Hitech	230	(90)	—	380	(150)
Legend Printing	Saatilene Hitech	255	(100)	—	355	(140)
CD						
Compact Discs	Saatilene Hitech	355	(140)	—	460	(180)
	Saatilene CD-Mesh	355	(140)	—	460	(180)

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Fabric Selection Chart

APPLICATION	FABRIC	MESH COUNT RANGE				
		inch	(cm)		inch	(cm)
CERAMIC						
Tiles First and Second Firing	Saatilene Hibond	140	(55)	—	196	(77)
Tiles Third Firing	Saatilene Hibond	230	(90)	—	420	(165)
Tiles Dry Firing	Saatilene Hitech	24	(9,5)	—	61	(24)
Colloid	Saatilene Hitech			—	86	(34)
GLASS						
Automotive Industry	Saatilene Hibond	168	(62)	—	305	(120)
Domestic Appliances	Saatilene Hibond	180	(71)	—	380	(150)
Building Sites	Saatilene Hitech	168	(62)	—	255	(100)
MISCELLANEOUS APPLICATIONS						
UV Varnishes	Saatilene Hitech	380	(150)	—	460	(180)
Solvent-Based Varnishes	Saatilene Hitech	158	(62)	—	305	(120)
Fluorescent Inks	Saatilene Hitech	158	(62)	—	305	(120)
Very Low UV Ink Deposit	Saatilene Hitech Half-Calendered	355	(140)	—	460	(180)
Uneven Surfaces	Saatilon	as application				
Projection Exposure	Saatilene Hibond	305	(120)	—	380	(150)
Fine Half-Tone	Saatilene Hibond	380	(150)	—	460	(180)
Very Long Print Runs	Saatilene Hibond	380	(150)	—	460	(180)
High Screen Output	Saatilene Hibond	86	(34)	—	508	(200)
on Difficult Substrates	Saatilene Hibond	196	(77)	—	460	(180)

NOTE:
1. Selecting a thinner thread diameter will improve ink flow and print definition.
2. Selecting larger thread diameter will increase fabric durability.
3. From mesh count 230 (90) and above, select dyed fabrics for optimum stencil resolution.
4. PW (Plain Weave) fabric will reduce the incidence of moiré, when printing half-tones.

Guidelines and Recommendations for Mesh Specifications

◆ FABRIC THICKNESS

Fabric thickness results from the combination of the number of threads, the thread diameter and the woven structure of the fabric. Major changes in fabric thickness result mostly from changes in thread diameter. Because it is not obvious that a thicker or thinner fabric will give a higher or lower ink deposit (a thicker mesh may have a lower relative open area) one less frequently considers this factor when selecting a mesh count. However the total fabric thickness is needed to calculate the theoretical ink volume of a mesh. The fabric measurement is obtained in an unstretched state.

* PERCENTAGE OF OPEN AREA

Figures for the percentage of open area have been provided to use as a guide in comparing one Saati mesh to another. Please be aware that in comparing different manufacturers' published percentage of open area data, figures will vary due to several factors. The most important difference being whether the manufacturer used nominal (before weaving) or real (after weaving) data in calculating the published figures. The interpretation of the conversion of the data from metric to English can also contribute to differences. For practical application, we advise you dial our toll-free hot line and speak to one of our technical representatives.

● THEORETICAL INK DEPOSIT

As a reminder, the T.I.D. specification is theoretical. It is to be used as the basis for comparison to other mesh counts' theoretical ink volumes. There are many other factors that influence ink deposit. For example, screen tension, substrate absorption, ink type, stencil thickness, squeegee variables, etc. One of our technical representatives can help you narrow down the mesh choices for testing, but actual print and measurement testing needs to be done to obtain the actual ink deposit for each individual shop. (A given mesh count may work well with one shop's variables and have a different result in another shop.)

■ RECOMMENDED TENSION LEVELS

The lower end of the tensioning range can be achieved with most stretching systems, providing provisions have been made to eliminate high stress points. The higher tensions should be used by experienced screen makers utilizing state-of-the-art stretching systems and procedures. (Refer to "Rapid Tensioning vs. Stage Tensioning" Tech Tip on page 37.)

▲ Provides the comparative fabric strength between mesh counts.

New mesh counts and/or thread diameters are added periodically. Please inquire.

SAATILENE® HITECH™
A high tension, low-elongation monofilament polyester for prolonged tensions at the highest levels. Made with special high tensile strength fibers that are uniquely woven, then heat-set by a proprietary process to heighten dimensional stability. You'll minimize your off-contact distances, reduce squeegee pressure and dramatically increase production speed. All of which means virtually no print distortion. Ideal for applications requiring critical registration, color control and uniform ink deposit. Hitech mesh is available in white, Ultra-Orange and Ultra-Yellow in widths from 40/45 to 145 inches. Mesh counts from 17 to 508 per inch.

Saatilene® Hitech™ Low-Elongation/ High-Tension Monofilament Polyester Mesh Specifications

	Mesh Count		Type of Weave	Thread Diameter	Mesh Opening	Overall Fabric Thickness◆		Percentage of Open Area*	Theoretical Ink Deposit●		Recom-mended Tension■	Specific Cross Section▲
	(per inch)	(per cm)	(TW or PW)	(microns)	(microns)	(inches)	(microns)	%	(cm^3/m^2)	(cu. in./sq. yd.)	(N/cm)	(SCS mm^2/cm)
1	17	6.5	PW	385	1180	0.0281	715	58	415	21.28	35-60	0.756
2	24	9.5	PW	280	810	0.0210	533	55	293	15.02	35-60	0.585
3	30	12	PW	260	580	0.0191	485	47	228	11.69	35-60	0.637
4	38	15	PW	200	475	0.0143	365	50	178	9.57	35-60	0.471
5	46	18	PW	160	400	0.0112	285	52	148	7.62	35-60	0.362
6	54	21	PW	160	330	0.0108	275	46	127	6.51	35-60	0.422
7	61	24	PW	120	290	0.0085	216	50	108	5.57	35-60	0.271
8	61	24	PW	145	275	0.0096	245	43	105	5.21	35-60	0.396
9	74	29	PW	120	220	0.0086	218	41	89	4.54	35-60	0.328
10	74	29	PW	145	190	0.0094	240	32	77	4.02	35-60	0.513

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Saatilene® Hitech™ Mesh Specifications

	Mesh Count		Type of Weave	Thread Diameter	Mesh Opening	Overall Fabric Thickness◆		Percentage of Open Area*	Theoretical Ink Deposit●		Recom-mended Tension■	Specific Cross Section▲
	(per inch)	(per cm)	(TW or PW)	(microns)	(microns)	(inches)	(microns)	%	(cm^3/m^2)	(cu. in./sq. yd.)	(N/cm)	(SCS mm^2/cm)
11	81 SDE	32	PW	70	245	0.0043	110	61	67	3.31	24-26	0.123
12	86	34	PW	100	185	0.0068	173	41	71	3.64	33-40	0.267
13	96	38	PW	90	170	0.0063	161	42	68	3.47	35-40	0.242
14	110	43	PW	80	150	0.0052	132	43	57	2.88	35-37	0.216
15	125	49	PW	70	130	0.0045	116	40	46	2.28	30-34	0.188
16	140	55	PW	64	120	0.0041	105	41	43	2.20	26-31	0.176
17	158	62	PW	64	90	0.0041	106	32	34	1.66	30-34	0.199
18	180	71	PW	55	80	0.0036	91	33	30	1.53	25-30	0.168
19	196	77	PW	48	78	0.0031	80	36	29	1.48	24-26	0.139
20	196	77	PW	55	70	0.0035	90	28	25	1.28	27-32	0.182
21	230	90	PW	40	68	0.0024	62	38	24	1.23	20-24	0.113
22	230	90	PW	48	55	0.0032	81	27	22	1.08	27-29	0.162
23	241	95	PW	40	65	0.0026	65	37	24	1.23	22-24	0.119
24	255	100	PW	40	55	0.0025	64	31	20	1.02	26-28	0.125
25	255	100	PW	48	40	0.0032	81	16	13	0.66	30-34	0.181
26	280	110	PW	34	53	0.0022	56	35	20	1.02	22-24	0.099
27	280	110	PW	40	47	0.0027	69	26	18	0.92	25-30	0.138
28	305	120	PW	31	53	0.0019	48	40	19	0.97	21-24	0.090
29	305	120	TW	34	47	0.0025	64	31	20	1.02	24-26	0.108

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Saatilene® Hitech™ Mesh Specifications

	Mesh Count		Type of Weave	Thread Diameter	Mesh Opening	Overall Fabric Thickness◆		Percentage of Open Area*	Theoretical Ink Deposit●		Recom-mended Tension■	Specific Cross Section▲
	(per inch)	(per cm)	(TW or PW)	(microns)	(microns)	(inches)	(microns)	%	(cm^3/m^2)	(cu. in./sq. yd.)	(N/cm)	(SCS mm^2/cm)
30	305	120	PW	34	45	0.0021	54	29	16	0.82	24-26	0.108
31	305	120	PW	40	38	0.0026	67	20	13	0.66	27-32	0.150
32	305	120	TW	40	41	0.0028	70	23	16	0.82	27-32	0.150
33	330	130	PW	34	39	0.0021	55	26	14	0.71	24-27	0.118
34	330	130	TW	34	41	0.0024	60	28	17	0.87	24-27	0.118
35	355	140	PW	31	38	0.0019	48	28	13	0.66	20-22	0.105
36	355	140	PW	34	29	0.0022	56	16	9	0.46	23-26	0.127
37	355	140	TW	34	32	0.0024	60	20	12	0.61	23-26	0.127
38	380	150	PW	27	35	0.0017	44	27	12	0.61	17-20	0.085
39	380	150	PW	31	29	0.0019	49	20	10	0.51	22-24	0.113
40	380	150	PW	34	25	0.0022	56	13	7	0.35	25-27	0.136
41	380	150	TW	34	28	0.0023	61	17	10	0.51	25-27	0.136
42	420	165	PW	27	30	0.0018	46	25	12	0.61	17-21	0.094
43	420	165	PW	31	25	0.0019	49	17	8	0.41	24-26	0.125
44	420	165	TW	31	30	0.0024	60	24	14	0.71	24-26	0.125
45	420	165	TW	34	25	0.0026	66	16	10.5	0.53	24-28	0.149
46	460	180	PW	27	25	0.0017	43	20	8	0.41	18-22	0.103
47	460	180	TW	31	23	0.0022	56	17	9.5	0.48	23-27	0.136
48	508	200	TW	31	18	0.0023	60	13	8	0.41	23-27	0.151

The Saatilene, Saatitex, and Saatilon mesh specifications provided are average values measured on piece goods (in a relaxed state) manufactured with yarns of perfect nominal diameter (cfr. international standards) and under normal hygrometric conditions (20 degrees C = 68 degrees F, 65% relative humidity). They are subject to normal variations of ±3% on thread count in cases of variations in the above-mentioned conditions.

ISO 9001

Certificato del Certificazione SGS ISO 9001 SGS

Saatilene® Hitech™ Half-Calendered Polyester Specifications

Mesh Count		Type of Weave	Thread Diameter	Mesh Opening	Overall Fabric Thickness◆		Percentage of Open Area*	Theoretical Ink Deposit●		Recom-mended Tension■	Specific Cross Section
inch	cm	TW or PW	microns	microns	inch	microns	%	cm^3/m^2	cu. in/ sq. yd.	(N/cm)	(SCS mm^2/cm)
355	140	PW	34	26	0.0020	50	13	6.5	0.33	20-29	0.127
355	140	TW	34	27	0.0020	50	14	7	0.35	20-29	0.127
380	150	PW	34	21	0.0020	51	10.5	5.5	0.28	22-30	0.136
380	150	TW	34	23	0.0020	51	12	6	0.30	22-30	0.136
420	165	TW	31	24	0.0017	42	16	7	0.35	20-28	0.125
420	165	TW	34	21	0.0020	52	12	6	0.30	25-33	0.150
460	180	TW	31	17	0.0018	45	10	4.5	0.23	23-29	0.135

SAATITEX®: A high-quality multifilament polyester. Available in widths from 40 to 145 inches and mesh counts from 6xx to 25xx.

Saatitex® Multifilament Polyester Specifications

Fabric Type	Mesh Count (per inch)	Mesh Opening (inches)	Overall Fabric Thickness◆ (inches)	Percentage of Open Area*	Theoretical Ink Deposit● (cu. in./sq. yd.)
6xx	74	0.0092	0.0059	46	3.52
8xx	86	0.0072	0.0059	39	3.01
10xx	110	0.0053	0.0051	33	2.04
12xx	122	0.0046	0.0047	32	1.94
14xx	127	0.0041	0.0047	27	1.63
16xx	158	0.0033	0.0041	27	1.43
18xx	168	0.0036	0.0039	36	1.58
20xx	175	0.0034	0.0033	34	1.48
25xx	196	0.0027	0.0032	28	1.22

SAATILON®: A precision-woven monofilament nylon. Due to its inherent elastic properties, it is ideal for printing on uneven and curved surfaces. Excellent abrasion resistance and ink passage. Available in white, Ultra-Orange, and Ultra-Yellow in widths from 40 to 80 inches. Mesh counts from 17 to 460 per inch.

Saatilon® Monofilament Nylon Specifications

Mesh Count (per inch)	Type of Weave	Thread Diameter (microns)	Mesh Opening (inches)	Overall Fabric Thickness◆ (inches)	Percentage of Open Area*	Theoretical Ink Deposit● (cu. in./sq. yd.)
17	PW	400	0.0461	0.0303	55	21.69
96	PW	90	0.0069	0.0067	42	3.64
110	PW	80	0.0063	0.0057	43	3.17
140	PW	61	0.0047	0.0043	44	2.46
158	PW	61	0.0039	0.0041	38	2.05
180	PW	61	0.0031	0.0044	32	1.84
196	PW	50	0.0031	0.0033	37	1.58
230	PW	50	0.0024	0.0037	29	1.38
255	PW	44	0.0022	0.0032	31	1.28
280	PW	38	0.0020	0.0028	32	1.17
305	TW	37	0.0019	0.0028	32	1.17
305	PW	37	0.0017	0.0026	25	0.87
305	TW	38	0.0017	0.0028	27	0.97
305	PW	38	0.0017	0.0026	25	0.87
330	TW	38	0.0016	0.0029	26	0.97
355	TW	37	0.0013	0.0027	20	0.71
380	TW	37	0.0012	0.0028	21	0.76
420	TW	30	0.0012	0.0023	25	0.76
460	TW	30	0.0010	0.0024	21	0.71

SAATILENE® CD-MESH: Compact discs printing requires a series of features from screen fabrics such as: tensile strength, elevated tension, stability, stencil durability and reliability. This is due to the prevailing conditions when printing CDs: long runs, fast printing speed, good ink permeability, high job output, quick press set up and fast and efficient screen recycling. Saatilene CD-MESH is the fruit of the latest technology in fabric make-up engineered for such an application where expectations are great. It offers tension stability superior to that of high modulus Polyester fabrics with a greater elastic memory and exceptional stencil adhesion. It enhances the reproduction quality of the finest half-tone dot, and can be recycled maintaining the same properties.

New mesh counts and/or thread diameters are added periodically. Please inquire.

Saatilene® CD Specifications

Mesh Count (inch)	Mesh Count (cm)	Weave	Nominal Thread Diameter	Mesh Opening	Free Opening	Fabric Thickness◆	Theoretical Ink Deposit●	Specific Cross-Section	Maximum Recommended Tension■ From-To
inch	cm		µ	µ	%	µ	cm3/m2	mm2/cm	N/cm
305	120	PW	34	44	27	54	15	0.109	24-26
305	120	PW	40	35	18	63	11	0.151	23-26
380	150	PW	31	31	22	47	10	0.113	22-24
380	150	PW	34	23	11	56	6	0.136	25-27
460	180	PW	27	22	16	41	7	0.103	18-22

PW: Plain Weave (1:1)

The above are average values measured in relaxed state, manufactured with yarns of a perfect nominal diameter. (cfr. international standards), under normal hygrometric conditions (20°C=68°F, 65% relative humidity). They are subject to normal variations up to 7% if conditions vary from those stated above.

SAATILENE® PCB-MESH: Electronic circuit boards are fundamental to the perfect functioning of simple or sophisticated modern day equipment, machinery or mass communication systems. Their production depends on the highest know-how and reliable manufacturing components. Saatilene PCB-Mesh is a screen fabric specially engineered for the production of electronic circuit boards by the screen printing process. It is a product with all the necessary ingredients a screen fabric should offer for such a decisive end product: high modulus of elasticity for tight screen tension; fast tensioning procedures for the busy screen production department; optimum fabric stability.

Saatilene PCB-Mesh is produced with a special surface treatment that guarantees extremely high stencil durability particularly for indirect and capillary stencil systems, and the mesh manufacturing tolerances are certified to the ISO 9001 standards giving peace of mind when dealing with close tolerance applications. Saatilene PCB-Mesh is produced from the highest grade of monofilament polyester yarn, and is available in a choice of UV absorbent dyes to enhance the stencil edge quality of the most demanding circuits imaged with direct or capillary stencil systems. In all cases of primary and secondary imaging, select Saatilene PCB-Mesh from the range of Saati screen printing fabrics.

Saatilene® PCB Technical Specifications

Mesh Count		Weave	Nominal Thread Diameter	Mesh Opening	Free Opening	Fabric Thickness◆	Theoretical Ink Deposit●	Specific Cross-Section	Maximum Recommended Tension■ From-To
inch	cm		µ	µ	%	µ	cm3/m2	mm2/cm	N/cm
230	90	PW	40	68	38	62	24	0.113	24-32
255	100	PW	40	55	31	60	19	0.126	28-34
305	120	PW	34	45	29	54	16	0.109	26-33
355	140	PW	34	29	16	55	9	0.127	26-32

PW: Plain Weave (1:1)
The above items are available in standard widths of 115 and 158 cm (45" and 62").

SAATILENE® HIBOND™: Saatilene Hibond is a high tension/low elongation polyester monofilament screen printing fabric, offering added bonuses to the stencil maker and printer alike: time savings and stencil durability. While all screen fabrics imperatively require a thorough mesh treatment before stencil processing, Saatilene HIBOND is delivered ready to use. Its special factory finishing renders the use of adhesion promoters obsolete and in some cases reduces ghost imaging. Apart from the production time savings, it will extend the life of stencils from single to triple and more. This is a unique feature that is especially beneficial where printing conditions are unusually harsh either due to the nature of the substrate or that of the ink system.

Stencil Processing Time Chart

ACTION	TRADITIONAL FABRIC TIME (MINUTES)	SAATILENE HIBOND TIME (MINUTES)
Wetting of Fabric	0.5	0.0
Roughening	5.0	0.0
Rinsing	0.5	0.0
Drying	10.0	0.0
Wetting (film)	(0.5)	(0.5)
Screen Coating	5.0	5.0
Drying	20.0	20.0
TOTAL TIME	**41.0**	**25.0**
TIME SAVINGS: 40%		

New mesh counts and/or thread diameters are added periodically. Please inquire.

Saatilene® Hibond™ Technical Specifications

	Mesh Count		Weave	Nominal Thread Diameter	Mesh Opening	Free Opening	Fabric Thickness◆	Theoretical Ink Deposit●	Specific Cross-Section	Maximum Recommended Tension■ From-To
	inch	cm		µ	µ	%	µ	cm3/m2	mm2/cm	N/cm
1	110	43	PW	80	150	43	132	57	0.216	35-37
2	125	49	PW	70	130	40	116	46	0.188	30-34
3	125	49	PW	80	120	35	132	46	0.246	37-40
4	129	51	PW	70	120	38	118	45	0.196	30-35
5	129	51	PW	80	110	31	129	40	0.296	37-40
6	140	55	PW	64	120	41	105	43	0.176	26-31
7	140	55	PW	80	95	27	140	38	0.276	40-45
8	158	62	PW	64	90	32	106	34	0.199	30-34
9	173	68	PW	55	89	36	89	32	0.161	25-30
10	173	68	PW	70	65	20	120	24	0.261	38-42
11	180	71	PW	55	80	33	91	30	0.168	25-30
12	196	77	PW	48	78	36	80	29	0.139	24-26
13	196	77	PW	55	70	28	90	25	0.182	27-32
14	230	90	PW	40	68	38	62	24	0.113	20-24
15	230	90	PW	48	55	27	81	22	0.162	27-29
16	241	95	PW	40	65	37	65	24	0.119	22-24
17	255	100	PW	40	55	31	64	20	0.125	26-28
18	255	100	PW	48	40	16	81	13	0.181	30-34
19	280	110	PW	34	53	35	56	20	0.099	22-24
20	280	110	PW	40	47	26	69	18	0.138	25-30
21	305	120	PW	31	53	40	48	19	0.090	21-24
22	305	120	PW	34	45	29	54	16	0.108	24-26

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Saatilene® Hibond™ Technical Specifications

	Mesh Count		Weave	Nominal Thread Diameter	Mesh Opening	Free Opening	Fabric Thickness◆	Theoretical Ink Deposit●	Specific Cross-Section	Maximum Recommended Tension■ From-To
	inch	cm		µ	µ	%	µ	cm3/m2	mm2/cm	N/cm
23	305	120	TW	34	47	31	64	20	0.108	24-26
24	305	120	PW	40	38	20	67	13	0.150	27-32
25	305	120	TW	40	41	23	70	16	0.150	27-32
26	330	130	PW	34	39	26	55	14	0.118	24-27
27	330	130	TW	34	41	28	60	17	0.118	24-27
28	355	140	PW	27	43	36	42	15	0.080	16-18
29	355	140	PW	31	38	28	48	13	0.105	20-22
30	355	140	PW	34	29	16	56	9	0.127	23-26
31	355	140	TW	34	32	20	60	12	0.127	23-26
32	380	150	PW	27	35	27	44	12	0.085	17-20
33	380	150	PW	31	29	20	49	10	0.113	22-24
34	380	150	TW	31	34	27	55	15	0.113	22-24
35	380	150	PW	34	25	13	56	7	0.136	25-27
36	380	150	TW	34	28	17	61	10	0.136	25-27
37	420	165	PW	27	30	25	46	12	0.094	17-21
38	420	165	PW	31	25	17	49	8	0.125	24-26
39	420	165	TW	31	30	24	60	14	0.125	24-26
40	420	165	TW	34	25	16	66	10.5	0.149	24-28
41	460	180	PW	27	25	20	43	8	0.103	18-22
42	460	180	TW	31	23	17	56	9.5	0.136	23-27
43	508	200	TW	31	18	13	60	8	0.151	23-27

Other items available on request. PW: Plain Weave (1:1), TW: Twill Weave (1:2 - 2:2)
The above are average values measured on piece-good in relaxed state, manufactured with yarns of a perfect nominal diameter (cfr. international standards), under normal hygrometric conditions (20°C=68°F, 65% relative humidity). They are subject to normal variations up to 7% if conditions vary from those stated above.

METALESTER MESH: Metalester is a high precision screen printing fabric whose technical characteristics are the direct result of Saati's latest weaving technology combined with the most recent developments in the physical properties of the yarn. Metalester consists of a High Modulus polyester fabric coated by electro-deposition of a thin but controlled layer of nickel. This gives the product specific technical features that benefit a number of industrial screen printing applications that cannot be satisfied with conventional polyester fabrics.

FIELD OF APPLICATIONS

- Hollow glass
- Flat glass
- Ceramic
- Printed circuit

New mesh counts and/or thread diameters are added periodically. Please inquire.

FEATURES

- Low mesh distortion: The nickel incapsulation of the mesh considerably reduces fabric elongation helping to maintain the geometrical characteristics of the mesh
- High stability: The product's low elongation characteristics enhance the stability of the tensioned fabric, reaching optimum stabilization within a very short period of time
- Excellent abrasion resistance: The inherent nature of the nickel brings added value to Metalester in terms of mechanical abrasion compared to conventional polyester fabrics
- Antistatic: Nickel is an excellent conductor of electricity and therefore eliminates all risk of static build up
- Heat transfer: The excellent conductivity of Metalester makes it the right choice to print with thermoplastic inks
- Optimum stencil adhesion: Most stencil systems adhered extremely well to Metalester, particularly indirect photo stencil films

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Metalester Technical Specifications

Mesh Count		Weave	Thread Diameter	Mesh Opening	Free Opening	Fabric Thickness◆	Theoretical Ink Deposit●	Maximum Reco. Tension Levels■	Standard Width	
inch	cm		µm	µm	%	µm	cm3/m2	N/cm	cm	inch
61	24	PW	137	275	45	225	101	28	105	41
110	43	PW	87	142	37	142	53	28	105	41
140	55	PW	70	110	36	114	41	26	105	41
158	62	PW	75	88	29	116	34	26	105	41
180	71	PW	68	72	26	91	24	26	105	41
196	77	PW	71	62	22	93	20	26	105	41
230	90	PW	45	62	31	70	22	24	105	41
255	100	PW	47	55	29	71	21	24	105	41
280	110	PW	43	47	27	59	16	22	105	41
305	120	PW	43	41	24	60	14	20	105	41
355	140	PW	45	27	15	61	9	20	105	41
380	150	PW	41	28	18	51	9	20	105	41

(*) PW = Plain weave 1:1. Other widths available (cm/inch): 120/47 - 140/55 and 155/61

HAVER & BOECKER STAINLESS STEEL WIRE CLOTH

SaatiPrint is a direct importer of Haver & Boecker Stainless Steel Wire Cloth. Precision woven in Germany under ISO 9001 certification, Haver Wire Cloth is manufactured specifically for screen printing. Thus it provides the ink deposit uniformity and close-tolerance registration you need for your critical jobs. For maximum ink deposit control, choose Haver's exclusive CT Foil calendered wire.

Haver & Boecker's entire wire manufacturing process has been certified to meet the highest international quality standards (DIN EN ISO 9001). The most extensive of the ISO standards, the 9001 certification encompasses Haver & Boecker's product design, development, production, installation and service.

With input from screen printers around the world, Haver's research team has developed measuring methods and test procedures to perfect each phase of production. Haver's tight tolerances, from the selection of wire threads to the final inspection of each roll we deliver, guarantee reliability. So you can count on the integrity of the wire diameter, aperture width and cloth thickness.

You can achieve defined ink deposits easily with the nearly endless choices of Haver Wire. Within any mesh count, there's a range of wire diameters. In addition, any of these can be calendered. Available diameters range from 0.0007" to 0.0055" (accurate to within 1 micron).

Offered in plain or twill weave in widths from 36 to 60 inches and mesh counts from 60 to 500 per inch. (Ask us about larger widths and cut-to-size pieces.)

You'll receive an individual inspection sheet with every full roll. Each production phase is highly monitored with Haver's close- tolerance, electronic measuring systems.

New mesh counts and/or thread diameters are added periodically. Please inquire.

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Haver Stainless Steel Wire Cloth Technical Specifications

	USA Spec. ANSI/AWCI 01-1992		Metric Spec. ISO 4783-1 1989		Open Area	Cloth Thickness as Woven = AW		Theoretical Ink Deposit●		Theoretical Maximum Tension
	Mesh	Wire Diameter	Wire Diameter	Width of Aperture (Opening)		Average	Average	AW As Woven	CT Foil† Avg. Cloth Thickness -20%	AW As Woven
		d	d	w	Ao	D	D	Vth	Vth	Newton
	Threads/in.	inch	micron	micron	%	micron	inch	cm^3/m^2	cm^3/m^2	N/cm
1	60	0.0040	100	315	58	220	0.0087	128	102	75
2	80	0.0020	50	265	71	107	0.0042	76	61	25
3	80	0.0037	95	224	49	190	0.0075	93	74	90
4	105	0.0030	80	160	44	165	0.0065	73	58	84
5	120	0.0026	67	140	46	145	0.0057	67	54	67
6	125	0.0032	80	125	37	190	0.0075	70	56	100
7	135	0.0022	56	132	49	132	0.0052	65	52	53
8	145	0.0022	56	118	46	130	0.0051	60	48	57
9	150	0.0026	67	100	36	147	0.0058	53	42	84
10	165	0.0020	50	106	46	109	0.0043	50	40	52
11	180	0.0018	45	95	46	102	0.0040	47	38	46
12	200	0.0016	40	85	46	89	0.0035	41	33	40
13	200	0.0021	53	75	34	114	0.0045	39	31	70
14	230	0.0011	30	80	53	62	0.0025	33	26	26
15	230	0.0014	36	75	46	76	0.0030	35	28	37
16	250	0.0014	36	63	40	79	0.0031	32	26	41

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Haver Stainless Steel Wire Cloth Technical Specifications

	USA Spec. ANSI/AWCI 01-1992		Metric Spec. ISO 4783-1 1989		Open Area	Cloth Thickness as Woven = AW		Theoretical Ink Deposit●		Theoretical Maximum Tension
	Mesh	Wire Diameter	Wire Diameter	Width of Aperture (Opening)		Average	Average	AW As Woven	CT Foil† Avg. Cloth Thickness -20%	AW As Woven
		d	d	w	Ao	D	D	Vth	Vth	Newton
	threads/in.	inch	micron	micron	%	micron	inch	cm^3/m^2	cm^3/m^2	N/cm
17	250	0.0016	40	63	37	85	0.0033	31	25	50
18	270	0.0014	36	56	37	80	0.0032	30	24	44
19	270TW	0.0016	40	53	32	85	0.0033	27	22	54
20	280	0.0012	30	60	44	66	0.0026	29	23	32
21	300	0.0012	30	56	42	68	0.0027	29	23	34
22	325	0.0009	24	56	49	52	0.0021	25	20	23
23	325	0.0011	30	50	39	63	0.0025	25	20	32
24	325TW	0.0014	36	42	29	81	0.0032	23	18	53
25	400	0.0007	18	45	51	43	0.0017	22	18	16
26	400	0.0010	25	38	36	53	0.0021	19	15	31
27	500TW	0.0010	25	25	25	56	0.0022	14	11	39
	NEW High Tensile (HT)									
28	290	0.0008	20	67	59	45	0.0018	–	–	30

Haver's New High Tensile (HT) Stainless Steel Wire Cloth

A new grade of stainless steel wire cloth is now woven by Haver & Boecker. This High Tensile (HT) wire offers many new benefits. The 290 (0.0008″ diameter) mesh has a 59% open area, allowing you to print finer lines over longer production runs. Also, due to the new high tensile alloy, greater stability can be achieved while utilizing the new thinner thread.

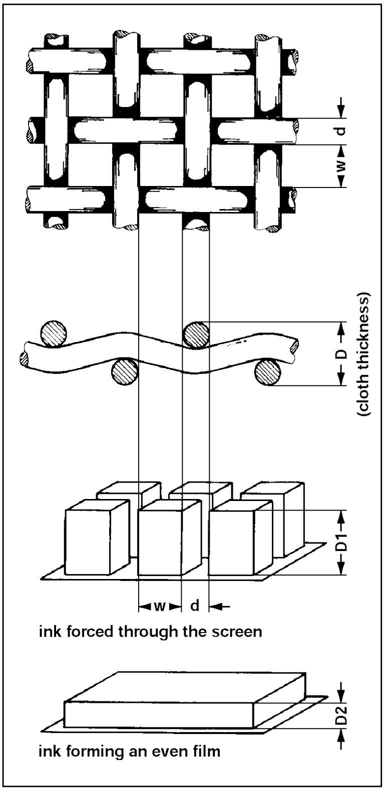
†This is an example of the most popular degree of calendering. A wide range of calendering is available. Most popular mesh counts are in stock. Width of rolls: 36″ (915mm), 40″ (1020mm), 48″ (1220mm), 60″ (1530mm). Please inquire about others. Length of standard rolls: 100 feet (30.5m). Custom sheeting to size is available. Please inquire.

Theoretical Ink Deposit

The theoretical ink deposit is an approximate value used to help select the most appropriate mesh count for the printing application. As seen in the diagram, the ink is forced through the wire cloth in cubes, whose volume is determined by the mesh aperture (w) and the cloth thickness (D). The cubes then flow together to form an even wet ink film of theoretical thickness on the substrate.

Since stainless steel wire cloth can be made with extremely thin wire diameters, it can deposit ink cubes with very small gaps between them. Therefore, the ink cubes have only a small distance to flow and form a uniform ink deposit, and thus, print definition with only the most minimal serration.

In addition to the wire cloth, other factors influencing the ultimate ink deposit include: ink viscosity, surface characteristics of the substrate, photostencil thickness and the squeegee speed, angle and durometer. The theoretical ink deposit (Vth) can be calculated in cm3 per m2 of wire cloth using the following formula:



$$Vth = \left[\frac{W}{w+d}\right]^2 \times D$$

WHERE:

w = mesh aperture (opening/microns)

d = wire diameter (microns)

D = cloth thickness (microns)

D1 = ink thickness (microns) at initial deposit

D2 = ink deposit (microns) after flowout

The Advantages Of Plain Weave Mesh For 4-Color Printing

QUESTION

We use a very high mesh count (380) and high solids content emulsion, which we coat to produce a ten-micron stencil thickness for a sharp image. Everything looks great, but we still run into problems when printing four-color process. Instead of nice round dots, the image is made up of irregular shapes, and some dots are missing altogether.

We know this causes problems with controlling neutral colors and flesh tones, and suspect it contributes to moiré, so what can we do to make a better stencil?

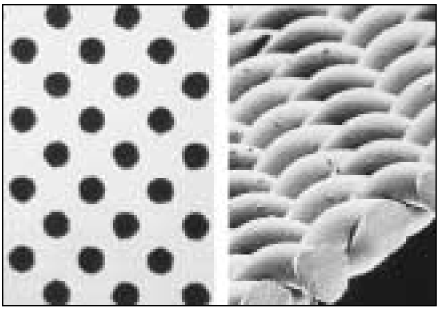
SOLUTION

It sounds like you are already making very high quality stencils, and they are probably ideal for fine line or even single-color halftone printing.

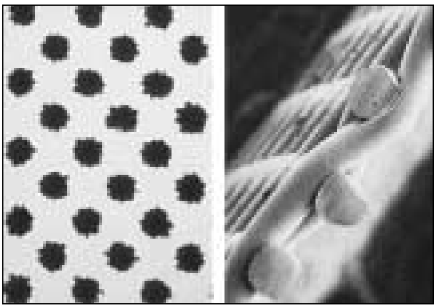
The problem is your ink deposit is way too high for four-color process printing, and you are suffering from some of the same problems that printers using UV-cured inks have had to tackle. Remember, plastisol inks are 100% "solids" too, and the stencil/mesh combination you describe will probably lay down an ink deposit of around 20 microns. This won't cause a problem with the first color down, and probably not the second either. The problems usually arise when trying to lay down small dots of the third or fourth colors. The ink deposit that has already been built up prevents the stencil from contacting the substrate evenly. In areas where the two don't touch, ink will not be pulled cleanly from the screen once the squeegee passes. Instead of a flat substrate, you are trying to print on something with a topography which resembles a microscopic version of Manhattan. The piled up dots of the first few colors produce a high-rise barrier between the screen and the substrate.

The particular 380 mesh you mention, is produced with a twill weave configuration where threads are inserted into every second space in the weave. This means that although it is very fine when measured by the number of threads per inch, there is still a lot of space for the ink to pass through. In comparison, plain weave mesh, where threads are inserted into every space in the weave, has a much lower percentage of open area, as well as a lower fabric thickness. This combined effect of the smaller openings with the thinner fabric would reduce your ink deposit tremendously, as the below comparison shows.

A further benefit of using plain weave mesh is that you can achieve good edge definition and sharp dot reproduction with a much lower stencil thickness. Instead of having to build up a ten-micron stencil in order to smooth over the long knuckles formed in the twill weave fabric, you



Print from a plain weave fabric.



Print from a twill weave fabric.

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could get away with a five-micron stencil thickness on plain weave mesh. This will shave even more precious microns off your ink deposit, and minimize the build-up that occurs and causes problems with your later colors. Simply lowering stencil thickness on the mesh you are using just now is not the answer. While you will print less ink, your halftones will suffer poor edge definition. Star-shaped dots are a major cause of problems with tonal balance and moiré, the very problems we are trying to control.

On a different note, another technique that would also help is the use of positives that have been separated with gray component replacement. With these types of separations, in areas of the design where yellow, magenta and cyan are all present, the density of the first three positives can be reduced. The difference is then made up at the end by printing with a heavier black than would be used with normal separations. The benefit of this method is that early ink build-up is minimized. This, in conjunction with the right mesh and stencil combination, will provide you the biggest window of operation for all the other parameters you have to control, once you get your screens to press.

Mesh Type	Fabric Thickness	% Open Area	Ink Deposit
380 TW.34	63 microns	17%	11 microns
380 PW.34	56 microns	13%	7 microns

HANDBOOK

Fabric Tensioning & Preparation

Practical Recommendations For The Correct Handling Of Fabrics

THE USE OF THE TENSION METER

The tension meter is above all a precision instrument and should be handled with care. Before engaging in any phase of tension control, always ensure that the instrument is zeroed. The reading indicated on the dial or display will correspond to the tension level of the fabric in the direction of the arrows shown on the instrument. Before recording the reading, tap the fabric gently near the base of the meter. Repeat several times, making sure that the reading is always the same. When measuring metalized polyester, lift the instrument rather than sliding it at the surface of the screen.

FABRIC TENSIONING WITH PNEUMATIC CLAMPS

In addition to the loss of tension that is created by the inherent nature of the yarn finding its own level of tension, additional loss may also originate from the frame itself not being able to fully oppose the pressure of the stretched fabric.

With the pneumatic clamps, this problem is alleviated as the clamps such as Saati Clamps create an inward bowing of the frame during the fabric tensioning phase. The movement created by the clamps reduces the loss of tension that is not attributed to the fabric.

In order to avoid inconsistency in tension, it is recommended to use clamps of the same make, with identical cylinder capacity, and same sized jaws. Short width jaws will lead to a more uniform stretching. Short width jaws will require more clamps per frame, but this will represent a higher total cylinder capacity for a given surface, and the working capacity of the pistons will be greater. However, for large size screens it is common practice to use wider jaws in which case a compromise needs to be made.

When setting up the equipment for screen covering there may be a small gap of 2-3 mm between each clamp. This will allow for each clamp to mold itself to the fabric movement in phase of tension. Larger gaps should not be permitted as this will be noticed on the finished screen as narrow bands of fabric with a lower tension.

Although each single clamp will pull to the predetermined setting on the regulator, care should be taken that the fabric is perfectly parallel to the set of clamps for each respective side. Failure to do this will produce uneven thread alignment in the respective direction which could lead to uneven mesh opening with adverse effects on print quality.

Before engaging the fabric in the clamps, check that they are all set on the same starting point, i.e. as close to the side of the frame as possible. The frame itself should be placed perfectly level and at such a height that the fabric is in perfect contact with its upper surface. Height adjusting screws are normally found on each clamp to regulate the level of the frame.

Experience will dictate what the correct height should be in order to prevent the base of the clamps to lift during tensioning, or in extreme cases, to overturn. Lifting of one or several clamps will affect the overall tension uniformity.

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FABRIC TENSIONING – STEP 1

Once the fabric has been carefully placed and locked in the clamps positioned as described above, the tensioning phase can commence.

Using the regulator control, start activating the clamps. When the regulator gauge reads 2 bars (10-20 psi), the tension meter can be placed on the stretched fabric. At this point the tension level can be entirely guided by it. It is a good practice to measure the screen at five control points to ensure that an even tension is being applied. Both warp and weft measurements should be taken. Bear in mind that it will take a minute for the air pressure to stabilize and the clamps to settle to a given tension level.

FABRIC TENSIONING – STEP 2

Once the fabric has reached the desired level of tension, it will eventually stabilize to a level of tension lower than that initially given. This "natural" tension loss can be minimized by letting the fabric rest for short periods during stretching. It is recommended to let the fabric stabilize itself for 10 to 30 minutes before adhering it to the frame. However, it is counterproductive to let the fabric stand for more than 30 minutes.

Once the adhesive is perfectly dry, the frame can be released from the action of the clamps. It is not advisable for the screen to be used for production immediately because the tension will finally stabilize to a lower level over a 24–48 hour period. If the stencils are produced within that period of time, problems of registration may be encountered.

General Recommendations For The Care And Usage Of A Tension Meter

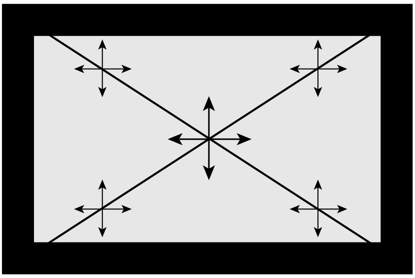
1. Always place your tension meter at a 90-degree angle to the mesh threads you are measuring. (Placing the meter on a 45-degree angle will result in getting a false "average" reading of the two thread directions.)

2. Don't rely on the tension only in the center of your frame/stretcher. Use a 5 or 9-point system, depending upon the size of the stretching area. It is important to achieve uniform tension within your image area to achieve maximum registration on press. It is also critical to check the tension in the corners. (A common cause of mesh ripping is over-stretched corners.)

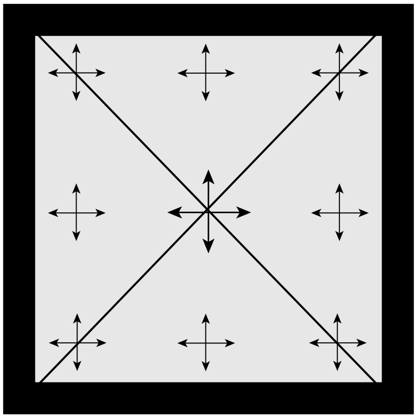
3. Handle the tension meter with care. It is not overly fragile, but dropping it will most likely result in the need to send it back to the manufacturer for repair. During the stretching process, when the meter is not on the screen mesh, place it either on its side or in its cushioned carrying case. (Placing the meter with the probe down on a hard surface causes premature/excess wear of the unit's spring.)

4. It is beneficial to have a spare meter, which is kept in a secured area. It not only serves as a control for checking calibration of the primary meter, but also serves as a backup when the primary meter needs to be sent back to the manufacturer for recalibration.

5. Check the calibration against the spare control meter approximately every 2 to 4 weeks (or more) depending upon usage and abuse. The procedure is simple and instructions are provided with the unit. If the meter is out of calibration to the extent you cannot adjust it, then it should be sent back to the manufacturer for recalibration.



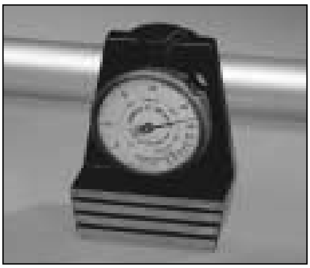
Tension check 5 points (warp and weft) on screen (I.D.).



Tension check 9 points (warp and weft) on screen (I.D.).

Tension Meter Use

SaatiPrint strongly recommends the use of a quality tension gauge to assure screen-to-screen consistency, screen tension uniformity, and accuracy. SaatiPrint suggests implementing a 5-point system across the screen area to guarantee uniform tension, and also to alert you to any excessive corner tensions.



Monitor screen tension easily and accurately with the Newman ST-Meter®.

Screen Tensioning
A Step-By-Step Guide

Optimum Screen Tension • Optimized Screen Performance • Extended Screen Life

INTRODUCTION

Care in mesh handling, loading, and tensioning control how well the screen printing fabric will perform throughout its production life cycle. All woven material, whether synthetic or stainless steel, has unique properties and working characteristics that need to be understood in order to reap the benefits from its intended use; the production screen. By following the SaatiPrint recommended tensioning procedures and tension levels, optimum print control and performance can be achieved.

There is no single definitive tension level recommendation that covers the several different synthetic materials available, along with the many mesh counts and thread diameters. Therefore, through extensive research and development, SaatiPrint has listed the safe working tension ranges for each of their screen mesh specifications. Each thread material type and diameter size has a specific "yield point" in both unwoven and woven states. This yield point is the maximum tension/elongation point a material reaches before it loses its memory or recuperative properties. The improper handling or tensioning of mesh, could exceed the material's yield point and result in the mesh breaking during screenmaking, printing or even sitting idle. Working within the safe or recommended tension levels will affect and control on-press variables which include print registration and ink release.

It is important for the screen maker and printer to be aware of the many production variables that will influence mesh performance, e.g.:

SCREEN MAKING VARIABLES

- Type of tensioning unit or retensionable frame system
- Frame format size/and profile
- Fabric stabilization and method used
- Working tension level

PRESS VARIABLES

- Squeegee pressure
- Off-contact height
- Image to frame size relationship
- Squeegee to frame relationship

Having an established tensioning procedure, will provide consistent screens time after time. The following procedures should be used as a guide in the handling and tensioning of mesh with your system. Incorporating some, or all, of the recommendations in this guide will result in consistency for screen tension and on-press performance. Plus they will extend the life of your screen.

Saati pneumatic clamps employ a unique "movable" design for "contact-less" uniform tensioning.

This innovative, easy-to-operate system stretches Newman Roller Frames® automatically in less than 2 minutes per frame.

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Pneumatic – Mechanical – Retensionable Frames

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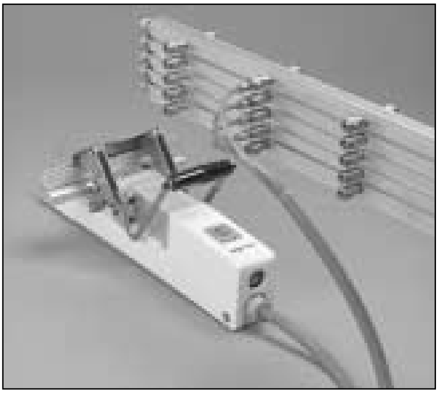
Regardless of the tensioning system, all fabric loading procedures are basically similar. Equipment manufacturers may have their own, or additional step-by-step instructions in regard to loading fabric or corner adjustment with their system. Aside from these two functions, there are other individual considerations based on the type of stretching system. Following are descriptions of pneumatic clamps, retensionable frames and mechanical systems, focusing on key areas that need to be addressed when tensioning screen mesh with that particular system.

Pneumatic Clamps

State-of-the-art pneumatic clamp tensioning systems, such as Saati clamps, offer two regulators (either standard or optional), which allow you to control both fabric directions (warp/weft – see below), when necessary. The format size will determine whether or not both regulators are used. Normally format sizes approximately 40" or under, will not require the use of both regulators. For format sizes above 40", both regulators are recommended in order to assure optimum tension uniformity, recommended tension level, and fabric stability.

Whether using a single regulator or dual set-up, begin tensioning the fabric in a continuous fashion until the target tension level has been reached. With the dual regulators, be sure to alternate evenly between warp and weft fabric directions. The target tension level should be reached within the first five minutes of tensioning. From this point, the operator must decide the level of fabric stability required for the print application. There is no set minimum or maximum amount of time fabric should remain in the tensioning system. However, in order to sufficiently stabilize fabric in a pneumatic system, SaatiPrint recommends waiting approximately 30 minutes before adhering.



The compact manifold plug-in system offers fast and easy setup.

WARP & WEFT

Fabric has two thread directions which are referred to as the "warp & weft." The direction running the length of the roll or bolt, is the warp direction. The opposite direction which is the width of the roll between the selvedges, is known as the weft. Historically, the warp & weft directions of synthetic mesh exhibited considerably different stretch or elongation characteristics. This was mainly due to the weaving process. With the advent of new "Hitech" low-elongation threads, along with improved weaving and finishing technology, the elongation has not only decreased significantly, but has become more equalized. This technology has made "stretch-and-glue" tensioning systems more viable, especially individual pneumatic clamp systems.

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Retensionable Frames

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Retensionable frames fall into two main categories; draw bar and roller. Each type has its own locking mechanism and is usually either flat locking strips or round-shaped nylon dowel rods.

Follow the frame manufacturers' mesh loading procedures, which are similar to other systems as far as working to opposite sides, and avoiding a circular set-up. Perform corner adjustments necessary, which are determined by the frame size and tension levels.

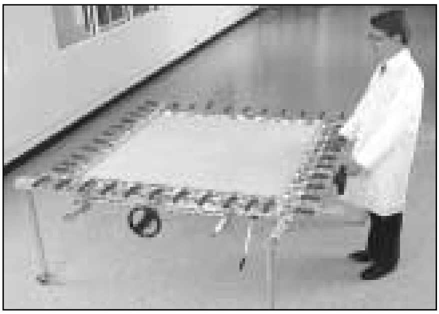
From this point forward, follow both frame and mesh manufacturers' recommendation, being sure to alternate from roller to roller and side to side, tensioning the mesh uniformly. Use a tension gauge to monitor tension both warp and weft directions, adjusting in 2-6 N/cm increments. Depending on target tension level and amount of stability needed, an additional or further corner adjustment or softening may be necessary. This is especially true when following a "print-reclaim-retension-print" procedure.

The use of a tension meter is critical in assuring uniform and optimum screen tension levels.

Mechanical System

There are a variety of mechanical systems available utilizing either rigid "one-piece" sides or individual clamps. Regardless of the type, be sure to lock mesh in as squarely as possible, always working to the opposite side. As in other systems, corner adjustment is equally important.

Depending on the model, either a 2-way or 4-way stretch is possible. Be sure to alternate tensioning in 2-4 N/cm increments to maintain tension uniformity in both warp and weft directions.



The H24-D is a highly precise, self-contained, continuously adjustable tensioning system. It is especially suited to thick film and surface mount screens and masks, glass and containers, precision graphics and electronics.

NOTE: mesh relaxation and tension loss will be more noticeable in both mechanical and retensionable systems versus a pneumatic system. This is due to the fact that there are no continuous forces being applied to the mesh, as in a pneumatic system that carries constant air pressure maintaining continual tension. Therefore closer monitoring and retensioning is necessary to achieve a stabilized working tension level with these systems.

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Corner Adjustment Procedure

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LOADING FABRIC (ANY SYSTEM)

1. Begin by aligning the mesh into the stretcher as square to the clamps as possible. Use the "selvedge" or fabric roll edge to guarantee a straight edge as you align the mesh. Be sure to place enough mesh into the clamping mechanism to allow for corner adjustment (see corner adjustment procedure). Pneumatic clamps must be aligned against each other leaving no spaces between clamps.

2. Start on one side and lock in the mesh completely with all the clamps in that row. Make sure that there is no pinching or wrinkles between clamps, which could later bind or possibly fracture the mesh while tensioning.

3. Now lock in the fabric on the opposite side. Be sure the mesh is square, and that there are no wrinkles or waves in the mesh as you lock it in. Start at one end and begin locking clamps one at a time, while holding the fabric some what taut and at a slight angle away from the previous clamp.

4. Lock in the third row with fabric in a relaxed state. Again, from one end, lock clamps one at a time, making sure that there are no wrinkles or pinch points. Once completed with the third side, move across to the last side and repeat step #3.

NOTE: with roller frames, the procedure is similar, except locking strips are utilized as the fabric locking mechanism.

CORNER ADJUSTMENT (ANY SYSTEM)

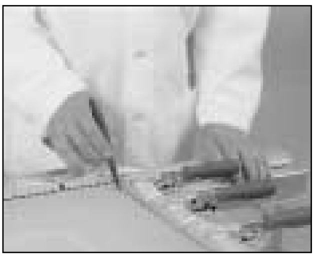
When using fine mesh counts, elevated tension levels, or large format frames, it may be necessary to corner adjust the fabric in the stretching set-up. This adjustment compensates for any excessive corner tensions, which could result in inconsistent tension from screen center to corner, or fabric fracture. The main cause for fabric breaking, especially while tensioning, is due to excessive corner tension.

ALIGNMENT MARKING

Draw a line against the corner clamp edge using it as a straight edge and make approximately a 6" line. *Repeat at all corner clamps.*

With roller frames, use pre-grooved lines in rollers as a guide to make a straight edge.

Use alignment grooves in roller to make adjustment line. If roller does not have alignment grooves, use locking strip channel.



Use clamp edge as a guide for marking adjustment line.

Use clamp edge as a guide for marking adjustment line.

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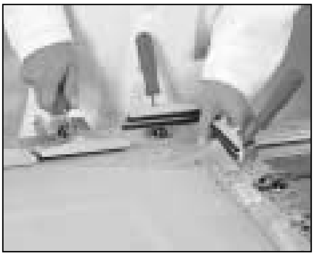
LATERAL ANGLE ADJUSTMENT

CLAMP SYSTEM
Release corner clamps, and while keeping fabric taut, move laterally in on an angle. The distance adjusted in, will be based on format size; A 40″ x 40″ format size will require approximately 1/2″ adjustment in.

ROLLER FRAME
Using rigid plastic squeegee, press in on locking strip or rods, while also pushing fabric inward, watching your lines move in laterally at an angle. Use caution as to not pinch or cut fabric in groove while adjusting.

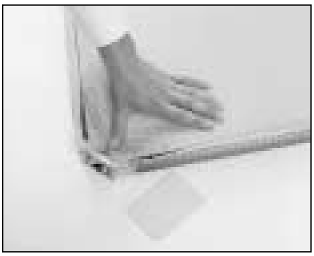
While applying pressure on fabric between rollers at corner section, press down on locking strip or rods using rigid scraper. Be sure mesh/line comes in at an angle.



Release corner clamps. While holding fabric taut laterally, bring fabric in at an angle.

Release corner clamps. While holding fabric taut laterally, bring fabric in at an angle.

CLAMP INTO POSITION
Bring clamp down onto fabric while angle adjusting, making sure both corner clamps have been adjusted evenly. Be sure no wrinkles are clamped in and avoid any fabric pinching between clamps.



Check for uniformity measuring angle adjustment from both rollers.

Once proper angle adjustment has been made, clamp down, locking fabric into position.

Once proper angle adjustment has been made, clamp down, locking fabric into position.

Using Proper Tensioning Techniques To Achieve The Desired Tension Level

QUESTION

I am using 305 PW 34 and I can only tension my screens to 12-18 newtons with my roller frames, and my mechanical stretch-and-glue system. I know the fabric manufacturer states that the fabric can go much higher to approximately 18-27 newtons. Is it the fabric that is failing or is it my procedure?

SOLUTION

The greatest likelihood is that improper tensioning techniques are affecting the fabric's performance. In order for the fabric to perform properly, the screen must be stretched properly. The following are a few things to check for in your system.

First, are you loading the fabric as square to the locking channels or clamps as possible? Fabric that is loaded and stretched at an angle will not reach recommended tensions because of the uneven forces exerted on the fabric. To avoid this, you should use the selvage edge, or a torn edge, as a guide when locking your fabric into your stretching device. (Remember that when you tear fabric, it will tear straight.) Once the first side is locked in as square as possible, move to the opposite side, and again lock the fabric in as square as possible. Make sure there are no wrinkles caught in the locking system, as this could cause fabric failure. Now repeat the previous steps on the remaining two sides.

Second, are you softening the corners? If you are softening, is it enough? The major reason fabric fails during stretching on roller frames and mechanical systems is because the corner tension is higher than the tension in the image or print area. Excessive corner tensions can be detected by the use of your tension meter. Place the tension meter in several areas, including corners of your frame, and look for hot spots, (where the tension is at least two newtons higher than the print area). If you find one of these hot spots, the corners need to be softened further. Check your manufacturer's recommendation for corner softening techniques, or contact Saatiprint for a free copy of our four-color stretching brochure that explains this procedure.

Another common problem is that you may be over tensioning in one direction, and under tensioning in the other. You may notice that as you tension in one direction, it affects the tension in the opposite direction. With roller frames, you must pay particular attention to the tension in both directions. If you make an adjustment to one side, you must make the same adjustment to the opposite side. If you do not, you could run the risk of skewing the threads, which would cause the fabric to fail.

One final note, you should make sure your frame is true/flat, not warped, and free of sharp edges and burrs.

How To Avoid Mesh Problems When Tensioning A Retensionable Frame

QUESTION

We have a problem with our 180 mesh screens. We use Roller Frames, and like to re-tension our screens right up to the maximum level recommended for each fabric. The problem we have run into however, is that some of the threads in the mesh are breaking. This eventually causes the screens to split. We originally thought the problem was caused during printing by hard particles in the ink tearing up the mesh. (Only the threads that go across the screen are breaking.) However, our ink supplier assures us that the ink is not the cause. We try to keep the screens nice and even during re-tensioning by keeping the mesh wrapped about the same amount around each roller, and so far we have not had any problems with our fine mesh screens. Any ideas?

SOLUTION

This is an interesting problem, and one that highlights the intricacies of such a seemingly simple task as stretching a piece of screen mesh. Over time, printers such as yourselves, who test the upper limit of the fabric's tension-holding ability, will eventually encounter additional problems. (Above and beyond those caused by the normal gremlins at work in the screen room.)

Your problem with the 180 mesh in this case is probably caused by having a gross imbalance in the amount of tensioning taking place on the warp and weft threads of the mesh. This situation can occur after multiple re-tensionings, even though the finished tension level you measure on the screen may actually be what you require.

The root of the problem is that with any mechanical stretching system, and this includes self-tensioning frames, there are an infinite number of ways to arrive at any particular tension level. You have no doubt noticed that when working with high-tension screens, that any additional tension applied in only one direction will actually increase the tension in both directions. As a result of this effect, it is possible to over-tension the warp (threads which run the length of the bolt of fabric), and under-tension the weft (threads which run from left to right), or vice versa, and still arrive at your target tension level.

In this case, by keeping an even amount of wrap around all four rollers on a rectangular frame and going through multiple re-tensionings (rather than keeping the tension even) you have over-stretched the mesh in one direction.

The situation can be made even more severe if you are using a regular polyester mesh, and you orient the fabric so that the weft threads line up with the short side of the frame. This is because in the normal state of affairs, regular polyester exhibits higher elongation of the warp threads, compared to the weft, in order to reach the same tension level. (Unlike Roller Frames, this is compensated for automatically on pneumatic stretching systems based on individual clamps.) This difference in elongation values is not always the case with all types of mesh. Hitech high-tension/low-elongation polyester fabric, in addition to holding more stable tension, offers the major benefit of the warp and weft elongation being nearly equal.

With a 23″ X 31″ frame, for example, if you attain a fabric wrap of 1″ around all four rollers, then this would correspond to 8.7% and 6.5% elongation of the mesh in the short and long directions respectively. As long as the warp threads of the mesh are aligned with the short side of the frame, the end result would be a very tight screen with even tension. This would happen automatically if you stretch with 40″ wide mesh straight off the bolt.

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If, however, you orient the mesh so that the weft threads are aligned with the short side of the frame, then any imbalance in elongation values for the warp and weft, instead of working for you, is going to work against you. The net result is that after re-tensioning, the weft threads could be stretched close to breaking point, with the warp still relatively under-tensioned.

The 180 screen you sent for evaluation had the selvage (with mesh specifications stamped on it) on the long side of the frame. Therefore, in this case it looks like you started with wider width mesh that was center slit, and then stretched so that the weft was indeed parallel to the short side of the frame.

Now keep in mind that if you do multi-color work with tight traps, or any process printing, you should always stretch your mesh on the frames with the same orientation in order to minimize registration problems. In fact, we would recommend that you always try to run the weft threads in the long direction. Having the squeegee stroke run with the weft will aid in holding tighter registration, and will improve your overall print performance.

The orientation of the fabric on the frame could probably explain why you have not run into thread breaking and mesh splitting problems with your other mesh counts. In some situations it may not be possible, or economical, to stretch screens to print with the weft due to frame size versus fabric width considerations. In these cases, it is of utmost importance to closely monitor your stretching procedure, and alternately advance the tension in only 2 n/cm increments as you switch between the warp and weft. Although more time consuming, this will prevent over-elongation and breaking of the threads, and is a better way to balance the tension than comparing the amount of fabric rolled around each side of the frame.

Is Stretching On An Angle (On The Bias) Beneficial?

QUESTION
We were told that stretching our screen mesh onto the frame at an angle, instead of square, would improve our print quality. Is this true, and if so what is the best angle?

SOLUTION
The advice you received was partly correct, in that under some circumstances it can improve print quality some of the time. However, it offers little if any benefit for most types of printing, and requires a different, (and probably more costly approach) in your methods of stretching screens.

The types of printing that benefit from angling the mesh on the frame include those where the artwork consists mostly of thin, straight parallel and perpendicular lines, such as those in circuitry, name-plates or panels. In these cases, the lines print better because they are at an angle to the mesh threads.

Some other types of printing benefit from angling the mesh on the frame because the squeegee then runs at an angle to the mesh threads. For instance, this is the case with the very fast printing speeds involved when decorating compact discs. Angling the mesh in relation to the squeegee results in improved flow and transfer of the UV-cured inks.

These benefits, although substantial for some types of printing, and maybe even critical for success in the above-mentioned applications, will not be realized with most types of printing. In fact, most of the time the drawbacks associated with angling the mesh on the frame will more than offset any perceived benefits.

It's not just a question of increased cost, where you need to use a longer and wider piece of fabric to accommodate a frame at an angle, there are also some technical arguments for why it's not a good idea.

You may suffer some unexpected distortion of the printed image, which will be especially exaggerated if you use an oversized squeegee, or excessive off-contact, in conjunction with too much squeegee pressure. This can also show up as increased difficulty in achieving registration when printing multi-color images, particularly in larger formats.

If you use self-tensioning frames, then stretching at an angle, or on the bias as it is sometimes referred to, is definitely not recommended. Although not impossible, it is very difficult, and there are severe limitations on how much of an angle you can achieve, and the tension level that can be reached. First of all, there is a tendency to pull the mesh openings out of square, due to the initial tensioning and pre-softening of the corners, and this can have an effect on ink deposit, or even cause moiré.

The amount of distortion increases as the angle is raised or as the tension level is increased, and in addition to this, it is very difficult during stretching to achieve an even tension over the whole print area.

If you stretch and glue, even though you keep the mesh openings nice and square, and the tension even, the screen mesh seems to be more fragile at the upper end of the recommended tension range because the mesh is stretched square with the frame angled underneath. Things that you would normally get away with, such as scraping some emulsion on the screen with an old nicked-up scoop coater, or leaving haze-remover on for too long, will suddenly start to split the mesh for no apparent reason.

Now, having considered the possible benefits, and also the drawbacks, if you still want to try printing with your screen mesh stretched at an angle, then we would recommend using 22.5 degrees. This angle has been proven to work, and

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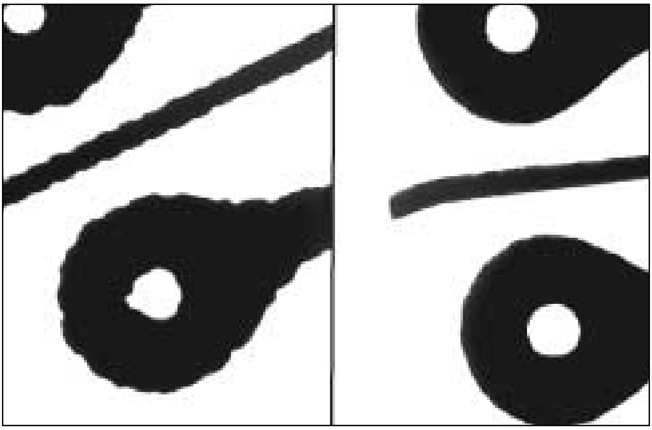
is used successfully to overcome problems in the types of printing mentioned at the beginning. If you don't have a protractor to measure angles, then you can use a ruler on a straight edge to measure ten inches along and 4.1 inches out. When you join the starting and finishing points, the angle of the line will be 22.5 degrees from your straight edge.

One last thing, if you print halftones or four-color process, don't forget that you may also have to adjust the angles of the dots on your positives in order to avoid the formation of moiré when exposing screens with your newly angled mesh.



Fabric printed with no angle. *Fabric printed with angle.*

Rapid Tensioning Versus Stage Tensioning

QUESTION

Is it necessary to leave my screens in the stretcher for 2 hours before gluing?

SOLUTION

In the past, it was thought that the mesh had to be tensioned in stages in order to achieve a properly stabilized screen. Recent studies have shown otherwise. It has been concluded that in using the rapid tensioning (RT) method, tensioned screens will normally result in a one newton or less difference in stabilized tension loss when compared with the longer stage tensioning methods.

The RT method differs from others, in that the tension is brought up immediately to the recommended tension level, without the stabilizing pauses or stages in-between. This allows the mesh to begin stabilizing immediately, and level off to the recommended tension level in a stabilized state much sooner.

The result of Saati's extensive research and testing has shown that there are definitive benefits achieved from the screen mesh when used in conjunction with the RT method. The Screen Printing Technical Foundation (SPTF) has also verified similar findings in regard to the benefits of rapid tensioning Update"). For detailed information concerning the SPTF's findings, contact the foundation at (703) 385-1417.

The most notable benefits the RT method provide are time and labor savings, without sacrificing print quality, or causing negative effects to the mesh characteristics or performance.

Although the RT method can be used with most stretching equipment or retensionable frames, our experience indicates that maximum performance can be achieved conveniently when using a pneumatically operated and controlled tensioning system with individual moving clamps (such as Saati Clamps). When incorporating the RT method into your screen-making process, careful monitoring and adjustments need to be made in order to achieve the optimum performance from the mesh to suit your individual screen and printing requirements. For example, attention must be given to assuring uniform stretching of the warp and weft, while avoiding excessive corner tensions.

For proper tensioning procedures, and more information on the RT method, please request "SaatiPrint's Tensioning Manual." This includes the most up-to-date instructions for mechanical and pneumatic type tensioning equipment.

Problems Associated With Insufficient Tension

QUESTION
We are having trouble getting enough ink laydown. We have even gone down as far as a 61 mesh for our white ink, and are still not getting good enough coverage. We coat our screens once on the print side, and twice on the squeegee side, but think there might not be enough solids content in the emulsion. Do you think a higher solids emulsion would help with our problem?

SOLUTION
In a word…no. The impact of using a thicker stencil (whether you make it by switching to a higher solids content emulsion or simply applying more coats of the brand you are currently using) will only be felt on the ink deposit of small detail, and around the perimeter of the larger detail in your design.

Once you move a certain distance away from the edge of the stencil, it can no longer exert any influence on the amount of ink that is deposited. The responsibility for that job falls to the mesh itself, with the important factors being mesh thickness, and probably more importantly its percentage of open area.

The 61 mesh that you used to print your white with poor results normally lays down a very thick ink deposit, actually way too thick for most people! Look at your printed samples, you will see that you do not have a problem laying down enough ink. You do, however, have a problem with poor coverage.

It looks like the underlying cause of your poor coverage problems is due to insufficient mesh tension in your screens during printing. Instead of laying the ink on top of the shirt by a smooth, continuous film, you are forcing most of it into and through the shirt. The result being that you have both poor coverage, and a very heavy hand caused by the thick ink film on the garment.

In these days of rigid metal frames used with off-contact pneumatic clamps, and self-tensioning frames, there is no good argument for going to press with less than 20 newtons of tension in your screens. By printing with a tighter screen, you will then need to reduce both the off-contact distance and the squeegee pressure. By reducing the squeegee pressure, you will then allow the ink to lay on top of the shirt, instead of being driven deep into the fabric. Screen tension is perhaps the single most critical element that determines just how much control you have over the printing process, and how successful it will be.

Indeed, there are now many people who take the view that 20N is insufficient tension for their needs. That's because even higher tension levels result in better registration, and faster printing speeds with less smearing and ink build-up when printing wet on wet. Along with numerous other benefits that are outside the scope of your current problem. However, don't try to run too fast before you can walk! Invest in some decent frames and/or a new stretching system, and tension your screens so they go to press with a minimum of 20N. With the right print set-up, you should then get good coverage with your white ink through an 86 or 110 mesh, or maybe even a finer mesh count, depending on the surface of the garment.

Don't be put off by the cost of some new frames. Your rewards will be a better looking and feeling shirt. Remember that a gallon of ink will go much further, and think of all the money you will save.

Choosing A Frame

With any frame, care should be taken to stay within the recommended limits of manufacturer of the profile sizes. One of our technical representatives can help you choose the correct profile size for your frame size.

WOOD FRAMES

Although wood frames may require a smaller initial cash investment, it will soon be realized that they are less cost-effective in the long run. For more critical jobs, wood frames do not provide the stability needed for registration, and require constant press adjustment. They hold moisture, which in turn can cause them to warp and bow. If screen tension and uniformity of tension are sacrificed where they are required, inefficiencies and quality problems occur.

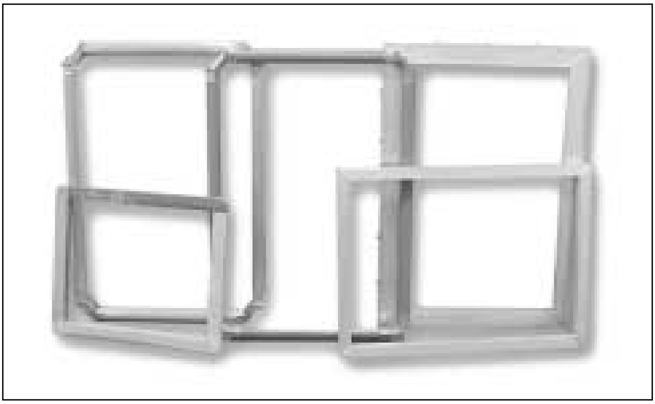
RIGID METAL FRAMES

These frames provide the rigidity and strength for higher tension levels, as well as a longer lifetime. Printing results will improve greatly over wood frames.

A quality made metal frame is constructed of steel (coated), aluminum or magnesium. Insist that these frames are welded and not screwed together. You can also select the finish; either ground mechanically or sand-blasted. Both work quite well, but some people have a preference for one or the other. If you do not have a stretcher that pre-bows the frame, insist on the thickest side-wall that is available so that the frame does not lose tension due to deflection of the fabric.

SELF-TENSIONING/ RETENSIONABLE FRAMES

Not only do these frames serve as their own stretcher, thereby eliminating the additional need for a stretcher and adhesive, but they provide the ultimate in control over screen tension. You can achieve optimum screen tension and uniformity throughout the screen, in addition to the longest and best possible life of the fabric. Achieving higher tension levels allows closer off-contact distances, which results in better print edge quality and maximized registration. Longer stencil and squeegee life are also benefits as a result of these closer off-contact distances.



We offer a wide variety of frames to meet your everyday needs.

How To Avoid Frame Adhesive Failure

QUESTION
My fabric is not sticking to my frame. I am using a cyanoacrylate product on a 380 PW 34 fabric. What am I doing wrong?

SOLUTION
Unfortunately, there is no one answer to your question. Several things can cause your adhesive to fail, whether you are using a cyanoacrylate, urethane or other type of adhesive. The following are some preventive measures you can take to avoid adhesive failure.

1. You must make sure the frame-gluing surface is not too smooth. (If you notice, new frames are sandblasted or roughened mechanically with a grinder; this is done to improve adhesion.) Sometimes a rough (80 grit) sandpaper is needed to give the frame some "tooth" or area that the adhesive can grab.

2. On the other hand, your frames should be clean of old fabric, ink, oils, and excessive adhesive residue. Intimate adhesive contact to the frame is critical, especially under high tension. Adhesive-to-adhesive bonds are not as strong as adhesive-to-metal or adhesive-to-wood bonds. Frames can be cleaned (prior to applying new adhesive) with a debonder solvent, or a solvent like acetone to remove adhesive, inks, dirt, and oils.

3. It is also very important that you select the right adhesive viscosity for each particular mesh count. In your case, on a 380 PW 34, an adhesive with a low-viscosity of 100 centipoise would be recommended. A good rule of thumb is:

Trade grades of adhesive are also available that are 600 centipoise for use on mesh counts from 110 to 355. Some adhesive viscosities are denoted by LV (low viscosity) and HV (high viscosity). Proper selection will ensure that the adhesive will flow through the fabric and provide a good bond by bridging the gap between the fabric and the frame.

Choosing Your Adhesive Viscosity

Mesh Count	Recommended Adhesive Viscosity
255 and up	100 Centipoise
255 and under	1500 Centipoise
110 to 355	300-600 Centipoise

4. When using two-part adhesives that need to be mixed, (versus cyanoacrylate adhesives that do not), it is important to follow the manufacturer's recommendation for the proper mixing ratio. Failure to do so can cause problems with curing times and/or solvent resistance.

5. When you activate a cyanoacrylate adhesive with either the pump or aerosol type activator (this speeds drying time), keep in mind that it only takes a light misting to start the curing process. If you spray too much activator on the adhesive, you can cause the adhesive to turn white or "bloom". This can affect the adhesive's strength.

6. Likewise, beware of the old adage, "If a little is good, a lot is better", when it comes to applying the adhesive. You only need a thin coating of adhesive to adhere the fabric to the frame. If the adhesive layer is too thick, the activator may only cure the top portion, while the portion that is in contact with the frame is still wet and may not cure for a few more minutes. If you feel you need a thick layer of adhesive for solvent resistance, add a second layer after the first layer is fully cured.

7. Check to make sure your frames are not warped, and that the face of the frames are completely level. If your frame does not lie flat, this may cause the fabric to remain raised off affected areas of the frame surface after you pass these spots with the adhesive applicator. A quick remedy for this would be to add weights on the inside and/or outside of the frame during gluing to bring the fabric into intimate contact with the frame. A one-inch steel bar stock can be used for this purpose.

Mesh Pretreatment & Degreasing

QUESTION
What is mesh pretreatment?

SOLUTION
Mesh pretreatment is the process of cleaning and preparing the screen mesh surface to improve stencil adhesion and eliminate coating defects, with the ultimate goal being optimum stencil performance and durability.

With virgin monofilament synthetic screen mesh, we recommend using an abrasive degreaser product, followed by a degreaser/pretreatment between subsequent stencils. For all other mesh, we recommend using a degreaser/pretreatment prior to stencil production and reuse.

Today there are carefully formulated mesh preparations available that go a step beyond conventional degreasers. For example, SaatiChem's Direct-Prep™ 2 actually treats the mesh surface. Direct-Prep 2 leaves a microscopic layer of an adhesion promoter on the surface of the mesh threads that improves film lamination and the coating and bonding of direct photoemulsions.

QUESTION
Why should I degrease my screen fabric? isn't it clean when I receive it?

SOLUTION
Yes, it is. However, handling during stretching can contaminate the mesh (skin oils, dust, etc.). These invisible contaminants can then impair stencil adhesion. Also, as we've described, good mesh preparation is more than just cleaning.

A properly degreased/treated screen surface should display a thin, even film of water with no beading. Inadequate mesh preparation can lead to:

1) splits, spots and fisheyes in the wet emulsion coating
2) pinholes
3) blotchiness due to uneven stencil thickness
4) dry spots or air pockets trapped under the capillary film
5) premature stencil breakdown due to poor adhesion

QUESTION
Isn't degreasing necessary only with capillary films?

SOLUTION
While it's true that the special degreaser/mesh pretreatment products were designed originally for use with capillary film, research has shown that the benefits apply to an equal or greater degree to direct photoemulsions. The products were sought for capillary films because of their ability to raise the surface energy of the mesh, enabling it to hold an even film of water on the surface.

The extra ingredient in these products that makes all the difference, was actually used in the past as a pretreatment to enable dye to adhere to polyester. As an illustrative point, consider the diazo sensitizer used in emulsions to be a form of dye. The special mesh preparation provides a link to attach the emulsion polymers firmly to the otherwise inert polyester surface. It is also the "wetting" action of the thin layer of adhesion promoter, when combined with an effective cleaner, that enables this type of product to improve the coating quality of your emulsion.

QUESTION
Why not use solvents or household cleaners to degrease my screen?

SOLUTION
Screen printing solvents will dissolve grease and oil (except silicone oils) on the fabric surface, but during evaporation these contaminants will redeposit themselves. Caustic degreasers should also be avoided because they increase the alkalinity of your waste water. If used in sufficient quantity, they may even raise the pH

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above the limit allowed by your local water treatment authority.

Household detergents are also unsuitable; they contain ingredients like lanolin and perfumes that leave a film on the mesh.

QUESTION

Why is fabric roughening or abrading necessary?

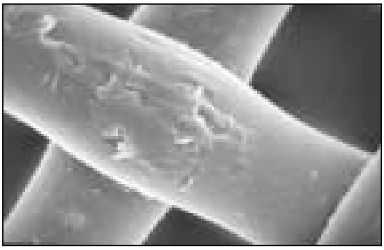
SOLUTION

Due to the nature of virgin synthetic monofilament mesh, it is necessary to gently abrade it before use to make it more receptive to good stencil adhesion. If you have ever seen polyester mesh under high magnification, you can attest to the surface of the threads being as smooth and featureless as polished glass. This, combined with the fact that polyester is a difficult substrate to stick to, means your emulsion coating needs all the help it can get to maximize adhesion. (The inherent surface traits of multifilament synthetic or stainless steel mesh already promote adequate adhesion.)

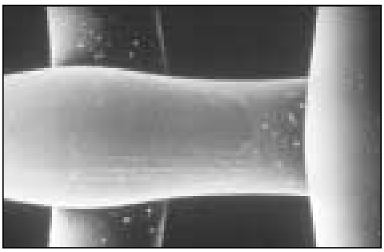
This becomes more and more important as the mesh count decreases; fewer threads mean less surface area, and therefore less to grip. A slight roughening of the surface increases the physical adhesion of the stencil to the fabric and enables it to better tolerate adverse conditions. For instance, it is better able to withstand the flexing and stretching that occurs if you ever have to print with a high off-contact. Particularly when the humidity starts to rise and your stencil is susceptible to losing some abrasion resistance.

Your stencil on a virgin polyester screen that hasn't been abraded can be compared to a coat of paint on an unprimed surface. Subjected to the battering of wind and rain, it begins to flake.

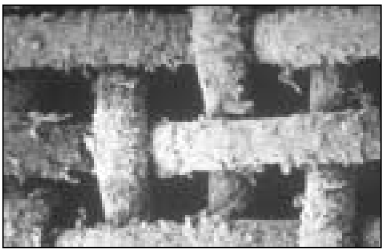
NOTE: household scouring powders should not be used. Their grain particles are too large, uneven and aggressive, which can cause clogging of the mesh openings or excessive thread damage.



Properly abraded fabric



Virgin monofilament fabric



Over-abraded fabric

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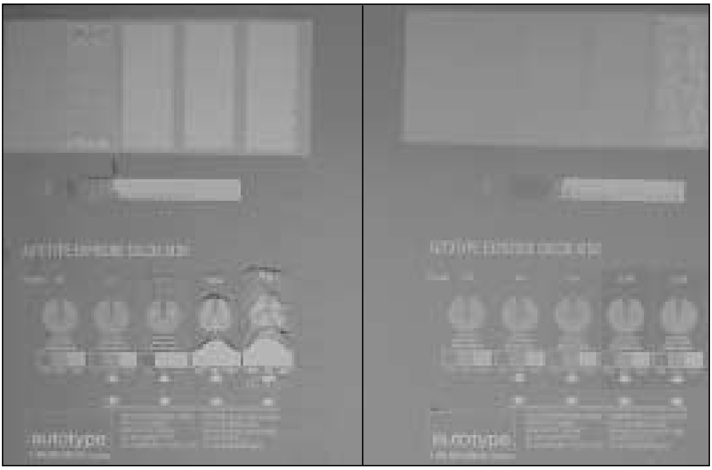
QUESTION
Why is good wetting action important to stencil adhesion?

SOLUTION
All stencil systems contain a percentage of water, so the more receptive a screen is to water, the better the stencil adhesion. Equally important is that the screen be receptive uniformly.

QUESTION
What are the special mesh preparation considerations when using a pure photopolymer emulsion?

SOLUTION
Correct mesh preparation is essential when using a pure photopolymer emulsion in order to maximize adhesion during stencil processing, and durability on press. Prior to coating, a mesh prep/degreaser containing a wetting agent should be used. This leaves the smooth, inert surface of monofilament polyester primed to adhere much better to pure photopolymer stencils. This is illustrated in the photograph where one half of the screen was degreased only with a detergent cleaner and the other side was degreased with SaatiChem's Direct-Prep 2.



Degreased with a detergent

Degreased with SaatiChem Direct-Prep 2

HANDBOOK

Stencil Processing

How To Reduce Pinholes

CLEANLINESS/QUALITY CONTROL
One of the main causes of pinholes is specks of dirt, lint fibers, adhesive residue from tape, or any other kind of contamination that can get stuck on glass surfaces in the exposure frame, or to the artwork, or even the coated screen itself. Airborne contamination needs to be avoided during coating, drying and storage. This is important particularly while the emulsion surface is still wet.

Maintaining good housekeeping procedures should prevent any build-up of debris on the floors, drying racks, etc., which could be disturbed and then land on coated screens. Exposure frame glass should be kept spotless and positives should be cleaned and inspected before use, if necessary. Artwork which is badly scratched will cause pinholes, and should therefore be re-made. Likewise, deep scratches on the glass inside the vacuum frame will cause pinholes in your screens. If the glass is badly scratched, it should be replaced, or at least reversed so that the scratches do not cast a sharp shadow onto the emulsion during exposure.

EMULSION HANDLING
Bubbles in the emulsion that transfer onto the mesh during coating are a major cause of pinholes. Diazo and dual-cure emulsions need to be stirred during sensitizing with a broad flat paddle until a smooth and even consistency is obtained. If you beat the emulsion with a stick, then it will take ten times longer to enable the trapped air bubbles to escape. The smaller the bubble, the longer it takes to rise to the top and pop. If the emulsion does contain fine air bubbles, then they may not cause a problem when coating fine mesh, since the mesh openings are too small to hold a bubble, but they will cause a problem with your lower mesh counts.

Even if you start with an emulsion free of bubbles, you can still expect to run into pinhole problems with your coarse mesh counts if you coat too fast. The turbulence generated in the emulsion as the scoop coater rides over the large woven knuckles of lower mesh counts is a great way to make foam. Scoop coaters with a sharp edge increase the likelihood of this occurrence due to the higher rate of shear on the emulsion.

NOTE: when coating a large number of coarse mesh screens, pour off the emulsion in the scoop coater (and let it recover) as soon as it starts to retain a lot of bubbles. Start coating again with fresh emulsion and you will have a lot less pinholes. (Refer to "What Are Optimum Drying Conditions" Tech Tip page 62-63.)

EXPOSURE
Optimum exposure, or rather avoidance of gross under exposure, is the third area that requires attention. The first thing to avoid is batch exposing screens of very different mesh counts. For example, a direct emulsion stencil on a 61 mesh needs twice the exposure compared to 110, and roughly three times when compared to 158 mesh. If you do batch expose, then only combine screens with a narrow range of mesh counts, and don't mix white mesh with dyed mesh screens. With a dyed fabric, even if the mesh count is the same, it still needs an approximately 50% longer exposure time to enable the emulsion to harden properly.

Also, avoid coating screens which have lost tension. The thick patch of emulsion that builds up in the middle of the screen is not only difficult to dry properly, it will also not expose correctly and will cause premature breakdown on press.

Finally, do some exposure tests to check how near or far you are from optimum exposure. You may use an exposure calculator or digital radiometer. (Refer to "Determining Optimum Exposure" Tech Tip

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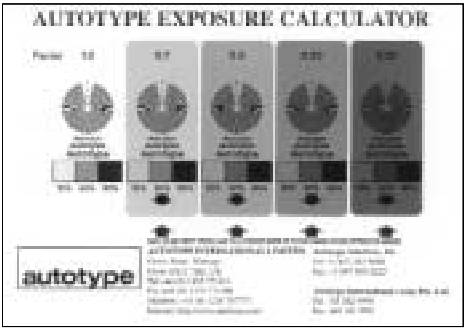
on page 66.) Another option is using a Saati 21-step grey scale, or stepwedge when exposing your production screens. Position the stepwedge where you can cover it with blockout before printing.

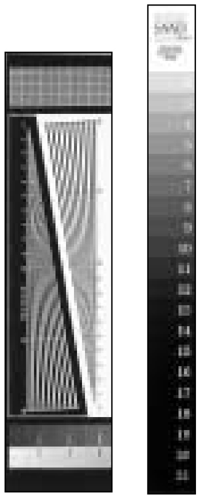
When you wash out the stencil, you should hold 6 or 7 solid steps on the wedge if you are at the correct exposure. For every two steps you are short, you need to double your exposure time.



Autotype exposure calculator.

TQM™ Digital Radiometer.

By using these tools to conduct exposure testing you can reduce your chance of pinholes which are caused by under-exposure.



Stouffer Resolution Guide and Saati 21-Step Sensitivity Guide

What To Expect From Your Stencil

PART 1 – INTRODUCTION
The purpose of this guide is to give an outline of commercially available stencil systems and the properties they possess. In doing so, we will touch upon the various technology employed, the effect of processing variables, and finally examine the effect of some of the factors that limit what is achievable.

PART 2 – STENCIL TYPES
Commercially available photostencils fall into four main categories. The first is known as Indirect Film, where the stencil imaging and developing process is carried out independently of the screen mesh. The finished stencil is applied to the mesh with gentle pressure, blotted with newsprint, and dried prior to removal of the backing film. Although capable of the highest quality reproduction, the thin edge of the finished stencil is very fragile and easily damaged, and therefore unsuitable for long print runs or for printing on difficult substrates. Indirect film is only suitable for use on finer mesh counts that are capable of supporting the fragile stencil. **See Figure 1.**

Indirect Film
- Highest resolution (processed away from the mesh)
- Excellent definition (short print runs only)
- Poor durability, 100's of prints
- Expensive
- Requires skill to process (chemical processing)
- fine mesh only

Figure 1

The second type of stencil is known as Direct Film or Capillary Film. In this case, a much thicker layer of pre-coated photographic emulsion, that has been manufactured to a precise thickness, is adhered to a wet screen mesh through capillary action. After drying and removal of the backing film, exposure and development produces a much stronger and more firmly adhered stencil than in the previous case, but still with the image quality associated with a film based product. **See Figure 2.**

Capillary Film
- Very good resolution and definition
- Medium durability, 1000's of prints
- Expensive
- Range of thickness available to cover most mesh counts
- Automation possible

Figure 2

With the third type of stencil, known as Direct/Indirect, the film is laminated to the mesh with a layer of photographic emulsion instead of water. Once this sandwich has dried, processing is carried out the same as for capillary film, but with the advantage that an even more firmly adhered and durable stencil is produced. The downside is that the stencil making process is more complicated and messy, particularly in larger formats, and is also more costly since both film and emulsion are required. **See Figure 3.**

Direct/Indirect
- Very good resolution and excellent definition
- Extremely durable, 1000's of prints
- Expensive, both film and emulsion required
- Messy process, requires skill
- Most suitable for small format

Figure 3

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That brings us to the last, and most commonly used, type of stencil which is known as Direct Emulsion. In this case the mesh is coated with a light sensitive emulsion, which when dry is imaged and then developed in the same fashion as capillary film. This is by far the least expensive method, in terms of material cost, and results in the most durable stencils. However it is also capable of producing poorer print quality than any of the film based systems, unless the correct choices are made in terms of emulsion type and methods of processing and bringing several variables under control. **See Figure 4.**

Direct/Emulsion
- Good resolution
- Definition poor-excellent, depends on processing
- Extremely durable, 1,000's plus prints
- Inexpensive
- Easy to automate
- Suitable for all size formats and any mesh count
- Widest compatibility with ink chemistry

Figure 4

PART 3 – TECHNOLOGY OF STENCILS

With the exception of indirect stencil films, which generally are thin coatings of gelatin containing an iron salt sensitizer, the other types of photostencil system, mainly direct emulsion and capillary film, which is really pre-coated emulsion, are based upon a resin known as polyvinylalcohol. Polyvinylalcohol possesses an unusual combination of three properties that make it uniquely suited to be used as the basis of most stencil materials. First it is a water soluble polymer, which means that stencil processing and developing can be carried out with water, rather than organic solvents. Second, it is highly solvent resistant, unlike most other water soluble polymers that tend to dissolve even more readily in solvents, and therefore stencils are able to stand up to a wide variety of different ink types. Third, polyvinylalcohol contains a link in it's polymer chain that is easily broken by the application of dilute aqueous solutions of sodium metaperiodate, (AKA emulsion remover). This means that after printing, the mesh can be recovered and reused by stripping the stencil without harsh chemicals.

In order to make capillary films and direct emulsions light sensitive, there is a choice of three basic types of technology, Diazo, Dual-Cure or Photopolymer. In addition, other ingredients such as fillers or bulking agents are added to increase the solid content and improve wet strength of the stencil during processing. The choice of sensitizers, and the type or combination of fillers used will determine the properties of the end product. Ancillary ingredients include pigments, surfactants which improve coating quality, and defoamers to kill bubbles during processing.

The simplest technology employs a diazo sensitizer which is actually a polymeric yellow dye, that is unstable and decomposes when exposed to actinic blue and UV light. When exposed, the diazo reacts with the polyvinylalcohol crosslinking the polymer chains and decreasing it's solubility in water. This enables the stencil to form on the mesh during developing. The other ingredients that are added during manufacturing of the emulsion determine what it's final properties will be. With diazo emulsions and films, the other main ingredient is known as polyvinylacetate. Polyvinylacetate is used to add bulk, increase solids content, and due to it's water repellent nature is also effective in increasing the wet strength of the stencil during processing by preventing over-

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swelling of the cross-linked polyvinylalcohol, and loss of detail. If enough polyvinylacetate is used then the final stencil can become water resistant enough to be used for printing water-based inks. The problem with polyvinylacetate however is that it is very sensitive to organic solvents. If a high level is used, then the excellent solvent resistance and easy reclaiming conferred on the stencil by the use of the polyvinylalcohol component is compromised. For this reason, diazo emulsions tend to fall into one of two categories, solvent resistant or water resistant. **See Figure 5.**

Diazo Emulsion

Solvent Resistant
- 20-30% solids content
- Easy to reclaim
- Not humidity or water resistant
- Inexpensive

Water Resistant
- 35-45% solids content
- Plastisol & water resistant
- No solvent resistance (can be difficult to reclaim)
- Inexpensive

Figure 5

With Dual-Cure emulsion and film, the diazo sensitizer, which is still used, is fortified by including an additional crosslinking system at the time of manufacture. This additional crosslinking system is used to reinforce, or in certain cases even replace, the polyvinylacetate component of the stencil. By combining these two separate crosslinking systems, each separately for the two main components of the emulsion, it is possible to engineer properties into the stencil that were mutually exclusive with diazo sensitized products. For instance water and solvent resistance, or high solids and easy reclaiming. For this reason, most manufacturers of stencil materials now offer a universal type of dual-cure direct emulsion that combines most of the properties of the "ideal" stencil. **See Figure 6.**

Dual-Cure Emulsion

Universal Type
- 35-40% solids content
- Solvent resistant
- Water resistant (non-textile)
- Easy to reclaim
- Moderately expensive

Specialty Types
- High solids content – up to 50%, or
- Permanent (with catalyst)

Figure 6

Photopolymer stencil products do not contain diazo, since they are manufactured with a light sensitive polymer. Emulsions are supplied presensitized and ready to use with no mixing required, and both photopolymer emulsion and film have a shelf life that is measured in years, and not weeks or months. (Diazo is affected not only by light, but also by heat and humidity). The other distinguishing feature of photopolymer is that exposure times are a fraction of what would be used for either diazo or dual-cure products. This is due to the very high sensitivity of the polymer that is used. The resistance properties of photopolymer fall into the same categories as those for diazo sensitized material, either solvent or water resistant. Having said that however, the water resistance of commercially available photopolymer emulsions does not yet rival that of diazo. Products designed for garment printing are really more suited for use only with plastisol inks, unless a hardener is used to reinforce the screen. The very fast exposure times achievable with photopolymer has also enabled the development of products that are suitable for use with extremely weak light sources, such as projection exposure. **See Figure 7.**

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Photopolymer Emulsions
(presensitized with no mixing)
Garment Printing
- 40-50% solids content
- Very short exposure time (1/4)
- Plastisol resistant
- No solvent resistance (can be difficult to reclaim)
- Expensive

Graphic Printing
- 30-40% solids content
- Very short exposure time (1/3)
- UV ink and solvent resistant
- Expensive

Projection
- 20-30% solids content
- Extremely fast exposing
- UV and solvent resistant
- Very expensive

Figure 7

PROCESSING VARIABLES

Now, a screen printing stencil has to perform four functions. Two are important for any type of screen printing, since the stencil must first reproduce the image that is to be printed, and secondly be resistant to abrasion and chemical attack. The last two functions are particularly important for high quality line or halftone printing, since the stencil can help to control the amount of ink that is printed, and is also responsible for controlling image accutance, more commonly referred to as print edge definition.

Regardless of which type of stencil system is to be used, there are two parameters that affect print quality, and these can be measured and controlled. They are the Rz value which regulates edge definition, and the stencil profile which contributes to ink deposit. **See Figure 8.**

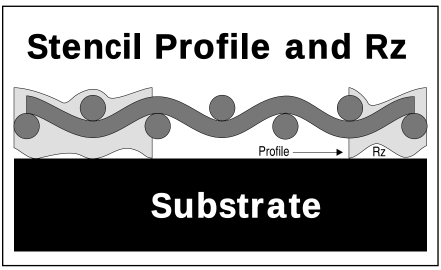

Figure 8

Stencil profile is used, along with the screen mesh chosen, to control ink deposit. For certain applications a thick stencil is beneficial, for other applications it is advantageous to minimize the stencil build up. Rz of the finished stencil controls edge definition of the print. For most types of printing, an Rz value of 10 microns or less will result in good edge quality. For highly demanding printing, such as small reversed text, or high line count halftones, a value closer to 5 microns is necessary. Below 5 microns, if the stencil becomes too glossy, then ink splattering or cobwebbing can occur when printing on glossy substrates.

Capillary film is manufactured in different thickness grades, each designed for optimum performance on a narrow range of mesh counts, and best results are obtained by selecting the correct grade for the mesh count being used. Excess water is removed from the mesh during processing with a light squeegee action, pressure is not required, and would in fact lead to detrimental results as the film could become overdissolved. If the correct capillary film thickness is used, the water that remains is sufficient to absorb half to two thirds of the original emulsion layer into the mesh. What remains comprises the stencil profile and controls the Rz value. **See Figure 9.**

With direct emulsion, the factors that are important in controlling the stencil parameters are the solids content/viscosity of the emulsion, and the coating procedure that is employed. High solids content is desirable as it minimizes shrinkage on drying. Shrinkage of the wet emulsion layer on drying leads to high Rz values

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Capillary Film
Thickness vs. Mesh Count

Below 86 mesh or to increase thickness, piggybacking of films is recommended.

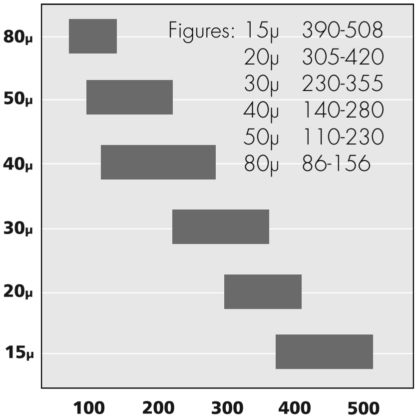

Figure 9

and poor print quality, even if you are using a high solids content emulsion, unless particular attention is paid to the method of coating. In order to optimize stencil profile, and minimize Rz, coating procedure has to be optimized for each application. In general, with a high solids content emulsion of around 40% solids, it is possible to achieve good results with simple wet on wet coating procedures. For very coarse screen mesh, such as 61, two coats on the print side followed by one coat on the squeegee side is all that is required due to the open weave and high percentage open area of the fabric. For 110 mesh, 2+2 should suffice. Once we get to 230 mesh, in order to duplicate the results that would be achieved with capillary film, a 2+3 procedure is required. The additional coats on the squeegee side of the screen in effect cause a build up of emulsion on the print side, which is where we need our stencil. The only time when an additional coating procedure is necessary, after the initial coats have dried, is for instance when printing four color process with UV cured inks. The very high mesh counts, such as 380 and 460, that are best at minimizing ink deposit, are also good at preventing emulsion build-up during coating. The easiest way to minimize both stencil profile, and Rz value, for this highly demanding application, is to face coat the screen after drying. This ensures that the thin stencils required to minimize ink deposit, will also provide a gasket fit onto the substrate and prevent ink from bleeding beyond the image area under pressure from the squeegee to cause sawtooth lines and the star shaped halftones that cause excessive dot gain.

Lower solids content emulsions are unable to bridge the coarsest mesh counts effectively with simple wet on wet coating methods, and this effectively limits the mesh count range on which they can productively be used. **See Figure 10.**

Direct Emulsion
Solids Content vs. Mesh Count

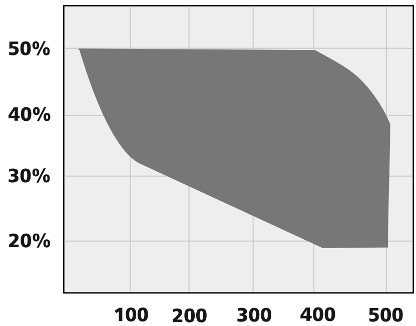

Figure 10

Regardless of which type of stencil system is used, correct exposure is of paramount importance in optimizing performance. Producing a screen printing stencil, even for use with the fine mesh counts used for printing halftones, involves exposing a coating that is very thick in comparison with those used for other photographic or imaging processes. Because of this, depth of cure through the stencil becomes a real issue. Poor through cure,

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or underexposure, will cause one or more of the following problems. Loss of detail during processing, excessive pinholes, scum leaking into and then blocking image areas, premature stencil breakdown during printing or clean-up, and last but not least, difficult or impossible reclaim. Remember, we are talking expensive screen mesh here.

Overexposure in comparison will cause detail to shrink on the screen, with eventual loss of parts of the image altogether, and this is usually most severe and easily noticeable with halftones.

A minimum of 20″ Hg of vacuum in the exposure frame is required to ensure good enough contact between the artwork and the screen during exposure. This prevents the undercutting of the image, and subsequent loss of detail, that occurs when light leaks under the positive. A good light source fitted with a metal halide type bulb is recommended to produce optimum results since there is a good match between the output spectrum of the bulb, and the maximum sensitivity of most stencil materials. It is also important that the placement of the lamp, and the reflector design, is optimized so as to ensure even coverage of the entire image area during exposure. Even coverage is essential for accurate reproduction of the image, as well as stencil durability. If coverage is very uneven then the exposure latitude of the stencil material may be exceeded, and areas of the screen may be either under, or overexposed, or sometimes even both on the same screen. In this respect, dual-cure emulsions possess the widest exposure latitude, although being overall very similar to diazo products in optimum exposure time. Photopolymer emulsions, since they expose in a fraction of the time and have inherently much less latitude, really do require more even exposure intensity in order to produce consistent results.

To determine optimum exposure, an exposure calculator or 21 step grayscale should be used. An exposure calculator usually consists of a repeating piece of artwork overlaid with a series of increasingly darker gray neutral density filters. With one test exposure, it is possible to simulate for instance five different exposure times. Examination of the developed and dried stencil reveals rectangles where the strong yellow color from residual unexposed diazo alters the color of the stencil. The trick is to pick the exposure factor for the rectangle that just becomes indistinguishable from the background, and this corresponds to the optimum exposure time. With a 21 step grayscale, an exposure time long enough to give 7 solid steps on a developed stencil is generally very close to the optimum. Since photopolymers do not change color on exposure, then the 21 step grayscale method is a more reliable method of determining optimum cure than an exposure calculator, although the calculator can be used to determine the level of resolution that can be achieved at different exposure times.

When using direct emulsion, it is not possible to gang expose a collection of different mesh counts and ensure that the correct exposure time is given. Longer exposure time is required for thicker coatings and the coarser the mesh, the thicker the layer of emulsion that has to be cured.

Another important variable that should not be overlooked as a cause of possible problems is screen drying. Both capillary film and direct emulsions require very thorough drying prior to exposure, since any residual moisture present in the coating will react preferentially with the photosensitive resins that are supposed to harden the stencil. When you expose a damp screen, you end up with a stencil that exhibits the symptoms of having been underexposed, except that no improvement is ever seen on increasing exposure time.

The type of artwork used can also have a big effect on the properties of the

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finished stencil. Most film positives will have a dense black image area, a high Dmax, and a clear background, a low Dmin. Vellum on the other hand rarely achieves a Dmax much above 1.5, and at the same time, the Dmin is usually around 0.3. What this means is that the vellum only allows 50% of the light to reach the stencil, and before optimum exposure is reached the insufficient Dmax has let light penetrate to the image area so that washout properties and detail are compromised. The expression, about stuck between the rock and the hard place, definitely applies to vellum.

Mesh preparation should not be ignored as an area that can affect stencil performance. Although screen mesh is thoroughly washed after manufacture, dust and oils from handling, along with adhesive overspray etc. cause contamination that should be removed prior to coating. Degreased mesh, although it may be squeaky-clean is, with the exception of stainless steel wirecloth, not very conducive to good stencil adhesion. Polyester mesh is woven from slick, smooth PET fibers. Water based paint, or photoemulsion, does not stick well to untreated PET. For this reason it is necessary to prepare the mesh properly in order to maximize stencil adhesion. Physical adhesion can be improved by lightly roughening the surface of the mesh with a specially designed abrasive degreaser. Chemical adhesion can be improved by treating the mesh with a meshprep containing a so called wetting agent. After rinsing, this leaves an adhesion promoting surface primer on the mesh that enables the stencil to adhere much better. Meshpreps are even available that combine degreaser, abrasive and wetting agent all in one product. The improvements seen in adhesion are most noticeable at underexposure. Photopolymer stencil materials benefit the most of all from good mesh preparation since they do not contain diazo that bonds to the fabric during exposure.

LIMITATIONS

Screen mesh comprises two parts, first the threads, and we need enough of these to support all of the detail in our image. Second the holes, the size and number of these, along with the stencil profile will control how much ink is laid down. Below 305 mesh, the main factor that influences ink deposit is the mesh count of the fabric, or how many threads per inch. Once we get above 305, the mesh count is less important, the actual thread diameter and weaving construction, plain or twill, becomes the dominant factor in determining ink deposit. Obviously the higher the mesh count, the finer the detail that can be supported on the screen.

However, the fact that there are threads in the way at all does place limitations on what can realistically be screenprinted. **See Figure 11.**

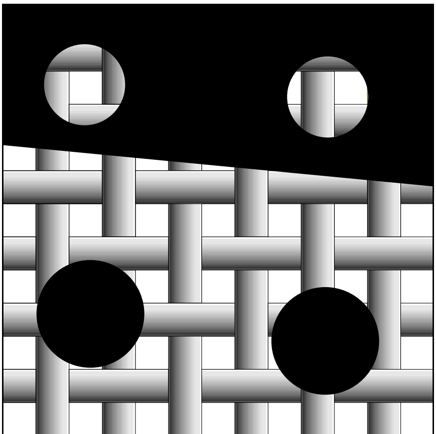

Figure 11

Minimum Size of Highlight Dot is 1 Opening + 1.5 Threads.

Minimum Size of Shadow Dot Needs 2 Openings + 1.5 Threads for Stencil

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As far as fine detail is concerned, there is a minimum size of opening in the stencil that will consistently allow ink to pass regardless of where it sits on the weave of the mesh. Once the size of the detail on the screen, fine lines or halftone dots, becomes narrower than one mesh opening plus one and a half thread diameters, then it can be obscured by passing over the threads and the knuckles of the weave where the threads cross. Choosing mesh with a thinner thread diameter can help squeeze out a little more detail, but at the cost of producing a more fragile screen. Mesh woven from thicker threads, as well as producing a more robust screen able to be used at a higher tension level for better registration with multicolor printing, provides better adhesion at the shadow end of a halftone range, or for holding fine lines with reverse printing. Once the small specks or strings of stencil that have to block the flow of ink, and differentiate between shadow tones or delineate text, become smaller than two mesh openings plus one and a half thread diameters, they may only adhere to one or two threads and lack sufficient adhesion to withstand the rigors of processing, never mind printing.

As an example, with halftones, the line count or dots per inch determines the tonal range that can consistently be printed on any particular mesh count. As the line count increases, the smaller dots enable viewing from a closer distance without the individual dots themselves being visible. However, increasing the line count effectively decreases the range of tones that can be held before highlights moiré, and then cease to print, and separation between midtones and shadows is lost as everything collapses to a solid print. This is illustrated for 380 mesh below.
See Figure 12.

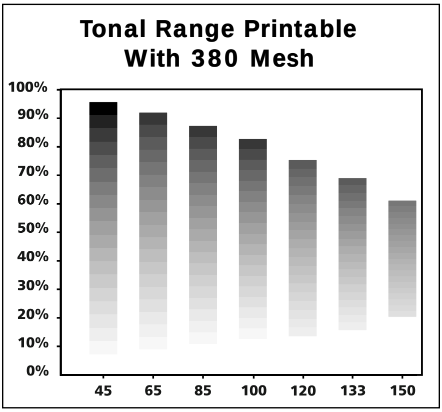


Figure 12

If a target is set of trying to print from 10% in the highlights, up to 85% in the shadows, for a print with good separation between all the tones of the halftone range, then each mesh will have a limit on how high the line count of the halftone can be if this is to be achieved.
See Figure 13.

Printable Tone Range

MESH COUNT	45 LINE	65 LINE	85 LINE	100 LINE	120 LINE	150 LINE
196	6-86%	13-71%	22-50%			
230	4-90%	9-78%	16-63%			
305	3-94%	5-89%	9-80%	13-71%		
355	2-96%	4-91%	7-85%	10-79%	14-70%	
390	2-97%	4-93%	6-88%	9-82%	13-75%	20-61%
420	2-97%	3-94%	5-90%	8-86%	11-80%	17-68%
460	1-98%	2-95%	4-92%	6-88%	9-84%	13-74%

Figure 13

A perfectly prepared stencil is in fact capable of resolving finer detail than it is physically possible to print, because of the intervening influence of the mesh. However, in order to make the perfect stencil, there are many screens to be burned, obstacles to be overcome, and variables to be controlled.

How To Match A Direct Emulsion's Print Quality Performance With That Achieved By Capillary Film

QUESTION

We recently switched from capillary film to high-solids direct emulsion, applied on an automatic coating machine, and are very pleased with the quality of our stencils on 230 and 305 mesh for solvent-based printing. However, we suffer from poorer print quality on our 380 mesh UV screens, most of which involve reverse printing of very fine detail.

Regardless of how we coat these screens, we are unable to match the stencil thickness achieved with capillary film. Is this the cause of our problems?

SOLUTION

As you have discovered, reverse printing of fine detail is probably the most highly demanding and critical test for the edge definition of a stencil. In order to match the quality produced from a film-based stencil when using a direct emulsion, even a high-solids emulsion combined with a coating machine, particular attention has to be paid to optimizing certain parameters.

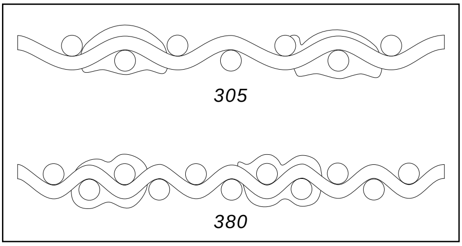
The fact that you are unable to match the stencil build-up obtained with capillary film when using direct emulsion is related to your problem, but is not itself the cause.

To cut a long story short, the root cause of your poor print quality when running UV can be traced back to the small percentage of open area present in the mesh used, (which is why you chose that mesh in the first place, in order to minimize the ink deposit).

The use of an automatic coating machine does enable you to transfer an even and repeatable amount of emulsion onto the mesh every time you coat a screen, and you are correct to use a high solids content emulsion to minimize shrinkage on drying. However, the problem with the very fine mesh used for printing UV is that it not only minimizes ink deposit, it also impedes the transfer of emulsion through the fabric when using the two-sided, wet-on-wet coating procedures that normally yield satisfactory stencils with more open meshes. You have obviously picked up this effect when monitoring your stencil thicknesses and compared them to what was obtained with capillary film.

The poor print quality is caused not by the lack of stencil build-up, but by insufficient smoothing over of the knuckles, which are formed during weaving of the mesh. The result being that during printing, the stencil will not provide the gasket seal required to prevent ink bleeding under non-image areas. In technical terms, the stencil Rz value is too high. Rz (surface topography). (Refer to "What Is A Stencil Rz Value?" Tech Tip page 61.)

Compounding the effect of the thin emulsion coating is the fact that the finer UV mesh probably has bigger knuckles to cover in the first place. That's because there is a good chance that with the mesh you are using, the same diameter thread was used to produce both 305 and 380 mesh. Below we have illustrated what happens, by comparing 305 and 380 mesh woven with 34 micron threads, a commonly used thread diameter for these mesh counts.



When the threads are packed more closely together, not only is the percentage of open area reduced from roughly 30% with the 305 mesh, down to around 15% with the 380 mesh (which is good for minimizing ink deposit), but the knuckles formed by the dense weaving structure are much more prominent and difficult to cover.

For the 305 mesh, you might expect to coat a high-solids content emulsion, say, two coats on the print side, with three coats on the squeegee side, and achieve something like a 6-7 micron build-up with a nice smooth finish. With the same procedure, the 380 mesh on the other hand, will only have a 1-2 micron

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stencil thickness, and will not print with the same quality as a film-based stencil.

Attempting to build up a thicker and smoother coating by applying additional coats to the squeegee side during wet-on-wet coating, is a futile task with mesh designed for UV printing. The mesh is not designed to allow the emulsion to pass through freely, and even if you apply an additional three or four coats to the squeegee side, you will be lucky to add a few microns to your stencil thickness. Meanwhile, the emulsion in the scoop coater on the print side of the screen is busy skinning over.

The surest way to guarantee the best print quality when producing this type of stencil, is to seal the fabric with a few coats on each side, and then dry it, prior to polishing up the print side of the screen with an additional coat. With this method, you will still not match the stencil thickness obtained with capillary film, as the additional coat applied after drying will add but a micron to the overall thickness. You should however, be able to match the print quality. Plus the fact that now that you are working with a thinner high-definition stencil, there may even be some benefits in terms of controlling ink deposit (and mileage).

Emulsion Selection & Coating Techniques For Coarse Mesh Counts

QUESTION

We use a high-solids content emulsion and are very happy with the results on our 158 and 110 mesh. We have problems, however, with our 61 mesh and we can't coat our 24 mesh screens at all because the emulsion drips right through. Do we need to find an emulsion with an even higher solids content?

SOLUTION

Not necessarily. You made the right choice in deciding to use a high-solids content emulsion, since you need high solids in order to cover your coarse mesh without too much shrinkage. However, the first thing we need to do is make a distinction between solids content and viscosity, or thickness.

Emulsion manufacturers are able to control solids content and viscosity independently of each other. High solids does not always mean high viscosity. In fact, many high-solids content emulsions are supposed to be low in viscosity because they were designed primarily for producing high quality stencils on fine mesh counts, where the flow properties of the emulsion are more critical. Obviously in your case, where you are using coarse mesh with a high percentage of open area, high viscosity along with the high solids content is an essential feature if you are going to avoid having problems with the mesh counts at the lower end of your range.

If you are using a diazo or dual-cure emulsion, you could try simply adding less water to the sensitizer when you mix it. If the emulsion is already too thin as supplied, or if you are using a pure photopolymer type that requires no mixing, then you may have to switch to an emulsion with a higher viscosity specification.

The second thing you need to address is ensuring that your coating method is optimized for the type of mesh you are using. As you go from 158 down to 24 mesh, the percentage open area of the mesh increases from 32% up to 55%. This, in conjunction with the fact that the openings are so much bigger, means that for the coarser mesh you really have to reduce the number of coats you apply. If you don't, too much emulsion will be transferred onto the fabric, and even the thickest emulsion will sag and drip if you lay it on too heavily.

For the 158 mesh screens, two coats on the print side, followed by two or maybe even three on the squeegee side, will produce a nice smooth finish to the dried emulsion. For the 110 mesh, two coats on each side should be sufficient. The last two coats should always be on the squeegee side to push the emulsion back where it belongs on the print side of the screen.

For the 61 mesh, cut back to only one coat on the squeegee side. And remember, these screens should always be dried flat with the print side underneath. By now you should have the emulsion onto the print side of the screen, and you want to make sure it stays there. Emulsion on the squeegee side of the mesh is more difficult to harden properly on exposure, and even when it is hardened, is more likely to suffer from abrasion and wear by the squeegee during printing. Thus causing pinholes and breakdown.

By the time you get to the 24 mesh, you need to adopt a different technique. In this case, apply one slow coat to the print side. Then, turn the screen and apply one slow coat to the squeegee side. Immediately after this, use your coater in the horizontal, untilted position to remove the excess emulsion from the print side of the screen by applying a scrape stroke. This will leave enough emulsion on the screen, but should eliminate the possibility for drips to form while the screen dries.

NOTE: one important point to remember is that the coarser the mesh, the slower you should coat in order to minimize bubble formation. With the coarser mesh, for instance 61, and particularly with 24 mesh, there is a tendency for air bubbles to get trapped in the mesh openings. As you probably know already, every trapped bubble is a potential pinhole.

Optimizing Automatic Coating Methods

QUESTION

We make over one hundred screens per day on 86 mesh all the way up to 355 mesh, and have recently bought an automatic screen coating machine fitted with a built-in dryer. Can you give us some advice on optimum coating methods so we get the best print quality from our screens without sacrificing productivity? If possible, we would like to use only one emulsion.

SOLUTION

You can achieve what you want with only one emulsion. However, in order both to ensure high quality, and maximize productivity, you will need to change your coating method to quite different techniques as you go from coarse to fine mesh.

With a 355 mesh, for example, the small percentage of open area with this mesh restricts emulsion transfer when simple wet-on-wet coating methods are used. This means that an awful lot of coats are required to fill, and then smooth out the mesh knuckles to optimize print quality even if you are using a high-solids content emulsion.

In this case, the built-in dryer should be used. The first coating/drying sequence will seal the mesh, and then an additional two coats on the print or substrate side, with drying in between, fills and polishes the coating so that print definition is optimized. This method will provide film-quality stencils with a very thin, but reproducible stencil thickness. Also, because the mesh/coating combination is so thin, drying times will be short enough so as not to affect your productivity adversely.

In the case of an 86 mesh, at the opposite extreme, the large mesh openings and high percentage of open area enable the emulsion to flow very freely. This means that you have to be careful not to put too much emulsion on the mesh!

If you are using a high-solids content emulsion, then the optimum settings we would recommend would be one coat on the print side with two coats on the squeegee side. The screen should then be removed for drying, while subsequent screens are coated. Remember, in order to get the best quality, you should dry these screens print side down. If you don't, then the emulsion will leak back through to the squeegee side. Even if you do manage to harden it properly during exposure, the stencil is not only going to print badly, it will get torn up by the squeegee as soon as you increase the pressure. This in turn will cause all kinds of pinhole and breakdown problems.

As you go higher in mesh count, you can stay with the simple wet-on-wet procedure, but you will need to increase the number of coats in order to maintain the optimum quality. For instance, with two coats on the print side and three coats on the squeegee side, the right emulsion on a 110 mesh will produce a better stencil than you could ever make with capillary film.

Once you get up to 230 mesh, you need to add an additional squeegee-side coat for a 2+4 procedure. However, anyone else reading this shouldn't be fooled into thinking that 2+4 means six individual coating passes. With the first two coats, both substrate and squeegee sides are coated simultaneously. After this, two more coats are then applied only to the squeegee side, for a total of four operations. In fact, since the coating trough on the squeegee side is slightly lower than the one on the print side, the squeegee side has effectively had the last three coats. The result of this is that with the right emulsion you produce a stencil with approximately fifteen microns thickness, with an Rz of around five microns.

Once you get to 305 mesh, you need to make a distinction between

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mesh woven from normal, or from heavy threads. If you are using a 305 mesh with a 34 micron thread diameter, then the 2+4 wet-on-wet method will work just fine. You can expect a stencil profile of about ten microns, and again the print quality will be similar to that achieved with capillary film. If however, you are using 305 mesh woven with 40 micron threads, then the wet-on-dry procedure developed for the 355 mesh is more appropriate. The reason for this is that the heavier threads reduce the percentage of open area and restrict emulsion flow. Also, the large knuckles formed where the thicker threads cross will not smooth over sufficiently with a wet-on-wet procedure, until the stencil becomes excessively thick. In this case, resorting to wet-on-dry keeps the thickness under control, while still providing the quality you seek.

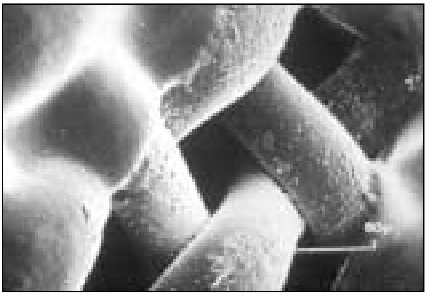
These three or four coating procedures should enable you to produce the high-quality stencils you are looking for on your range of mesh counts, while still allowing enough time for the productivity levels you need.

NOTE: you should use an emulsion with a high solids content. Lower solids content products shrink too much on drying, with the result that you tie up the coating machine by having to apply an excessive number of coats. Something around 35-40% solids would be ideal, but with a medium viscosity. There are plenty of dual-cure emulsions available with these properties. There are some higher solids content products around, but they may not have the versatility to work with the wide range of mesh counts that you are using. Also, the viscosity of some have a tendency to increase rapidly while you are trying to work with them on the machine. This can cause all types of problems, from varying stencil thickness to skinning over in the coating trough.

What Is A Stencil Rz Value And Why Is It Important?

Rz is a measure of the roughness or smoothness of a surface. It is an important screen parameter because it measures how efficiently the print side of the stencil controls edge definition when printing demanding artwork. For example, artwork containing fine lines or halftone dots. The stencil not only carries the detail of the image to be printed, it also has to function as a gasket to prevent ink from bleeding outside the image area under pressure from the squeegee during the print stroke. Any undesirable spreading of the ink typically causes a saw-toothed appearance on the edge of detail and fine lines. Plus it will obliterate fine reverse type. It also results in star-shaped halftone dots that cause dot gain and loss of contrast and detail, and can induce localized moiré.

In order to ensure a high-quality stencil, the Rz value must be controlled within narrow limits. Too rough, and the stencil will not gasket correctly onto the substrate. Too smooth, and the vacuum formed when printing on polished substrates will cause cobwebbing and splattering of the ink. Ideal values for most high-quality printing applications fall in the range of 4-10 microns.



Stencil with high RZ

Print result of stencil

Stencil with low RZ

Printed result of stencil

What Are Optimum Drying Conditions?

QUESTION #1
We try to keep the temperature in our screen coating/drying room around 75 degrees Fahrenheit, and use fans and a dehumidifier to dry our screens. However, we've noticed that during the summer, our busy season, screens take a long time to dry.

QUESTION #2
Also, we would like to switch to using a dual-cure emulsion, because we like the better detail and easier reclaiming, but these screens seem to take forever to dry. We have even had some get stuck down to the glass in our vacuum frame.

SOLUTION
The optimum drying conditions for coated screens are the same, regardless of whether you are using dual-cure emulsions, diazo emulsions, photopolymer emulsions, or even capillary film for that matter.

The reason you have had a problem with dual-cure emulsions, is not really that they are any more difficult to dry than other types. It's simply that prior to exposure, they have a softer surface finish than coatings made with other types of emulsion, due to the plasticizing effect of the photopolymer component.

The other factor could be excessive heat generated during exposure, which bakes the screen onto the glass, particularly when you are shooting a lot of screens and things really start to heat up. Or in your case, since you have already determined that you have a drying problem, the other factor is more likely to be residual moisture trapped in the screen. (Refer to "Determining Stencil Moisture Content" Tech Tip on page 64.)

Regardless of what type of emulsion you are using, residual moisture trapped in the coating prior to exposure can cause a whole host of problems. Stencils made with diazo emulsion may not be sticking to the glass in your exposure frame, but you are probably experiencing some other problems down the line. It may be excessive pinholes, premature stencil breakdown, or even poor reclaiming problems that you may not normally associate with a screen drying problem.

What are optimum drying conditions for any type of emulsion? Unless you are located in an environment like Arizona in the summertime, we would recommend that you split your coating and drying operations between two adjoining rooms. Degreased screens can still be dried in your coating room, but you should really have a separate environment to dry your coated screens. Ideally you should use a drying chamber, although how feasible this is depends on the size, and number of screens you are coating.

When drying coated screens, there are two important aspects. First, from a productivity point of view, you want screens to dry quickly. Second, from a quality point of view you want the screens to dry thoroughly.

By thorough, we mean drying down to a very low equilibrium moisture content. De-humidified air, being drier, is obviously more efficient at removing moisture from your coated screens than normal room air. But by itself, it is not necessarily the most effective method. The relationship between relative humidity, temperature, and drying capacity is fairly complicated, but fortunately very well understood. Heating and air-conditioning engineers routinely use psychrometric charts, which relate these varying parameters, when designing climate-controlled environments.

Thus, what we would like to do is try and explain the basis of drying in terms of these basic parameters. First, we would like to introduce the concept of vapor pressure. Vapor pressure exists when you turn a liquid into a gas. When the liquid is water, then vapor pressure is the driving force responsible for evaporation and condensation.

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When you put a wet screen in a drying room, the bottom line is that in order for the screen to want to dry out, there has to be a difference in vapor pressure. A difference has to exist between the vapor pressure of the moisture in the coating, and the vapor pressure of moisture already in the air. If there is no difference, then the screen will never dry. It is the size of this difference which controls moisture flow, and is important in determining: first, how fast your screens will dry, and second, how dry they ultimately become. *(We should add at this point, to beware the salesman who tells you that his emulsion has a higher vapor pressure than anyone else's!)*

The vapor pressure of the moisture in a wet coating is basically dependent on temperature, and the higher the temperature the higher the pressure. The vapor pressure of the moisture already present in the air is dependent on the dew point. This is the temperature at which condensation starts to form. Removing humidity from the air lowers the dew point, and hence lowers the vapor pressure.

The question is, what is the most effective way to maximize the difference between these two vapor pressures? Is it to raise the temperature of the coating? Or is it to dehumidify the air?

Let's start with, for example, a drying room at 75°F with a relative humidity of 60%. Just say we coat some screens and leave them to dry. Now if the fans being used to dry the screens change the air in the room to prevent moisture building up and saturating the air, the screens will eventually dry. A look at some charts, and a quick calculation, tells us that we have been working with a vapor pressure difference of 0.17 psi.

Now let's add a dehumidifier to the room, and say we are able to lower the relative humidity from 60%, and hold it down to a nice dry 20% (which requires a good de-humidifier). Consulting our charts, and performing the same calculation, shows that the vapor pressure difference is now 0.34 psi. This means we have twice the drying capacity, in terms of the evaporation load that the air is able to carry away from a wet emulsion coating. Screens should dry in about half the time, and equilibrium moisture content should be lower too. If however, we allow the relative humidity to creep up, due to a heavy load of screens for example, then drying efficiency falls off quite quickly.

Instead of using a de-humidifier, let's say we decide to use a heater to warm the air entering our drying room. If the air coming in was at 75°F and 60% relative humidity, and we warm it up to 100°F, although the amount of moisture in the air hasn't changed, the relative humidity drops to around 25% since warmer air has a much greater drying capacity. We are now working with a vapor pressure difference of 0.7 psi (due to the higher temperature of the coatings), and have four times the drying capacity of the original example.

Screens will dry faster and harder with the application of a little heat, than with a lot of de-humidification. In this case, we are also better able to cope with adverse conditions, such as a heavy load of screens to be dried, or even an increase in relative humidity of the outside air.

De-humidification does start to make more sense with very warm and damp conditions. But even dealing with temperatures of 90°F and relative humidity of 75%, you still get greater drying efficiency from a 10 degree rise in temperature, than from a de-humidifier able to remove 50 grains of moisture/lb. of air.

Determining Stencil Moisture Content

QUESTION

How can I tell when my screen is dry enough to expose?

SOLUTION

Number one, you can't tell by looking at it. Number two, unless it is very damp, you can't tell by feeling it either. You may get some indication when you have trouble peeling the artwork back off the screen, or when the emulsion sticks to the inside of the glass in your exposure frame. But by then, it's too late.

Your best bet is a contact moisture meter. This inexpensive electronic device will tell you exactly how much percentage moisture is being retained in your coated and dried screens by measuring directly on the surface of the emulsion.

As you know, you can definitely eliminate a lot of costly stencil breakdown problems if you ensure that your coated screens are thoroughly dried prior to exposure. As far as emulsion goes, the drier the better, in order to obtain a tough stencil.

There are some guidelines you can follow when measuring the moisture content of your screens to make sure that during exposure most of the sensitizer is reacting with emulsion and not water. If the moisture content of the coated screen is less than 4%, you should always get a nice tough stencil, assuming you are using the correct exposure time. Between 4% and 6%, you will notice a deterioration in wet stencil strength during washout, and you will also have more pinholes. This is most critical for emulsions that use a low diazo level in order to get a shorter exposure time. Above 6% moisture content, most emulsions will produce soft stencils regardless of exposure time, and you run a real risk of breakdown on press. In this case, depending on your run length, you may or may not have a problem when printing plastisol. However, you will have a problem if you try to print water-based inks. As coated screens become more damp, stencils will be progressively softer. Eventually you reach the stage where they suffer spray damage during washout, regardless of how long you expose your screens.

Once you are able to measure the moisture content of your screen, how should you proceed if it isn't dry enough? Typically, if the area where you dry your screens is affected by the weather to such a degree that it affects the way the emulsion dries, then simply leaving the screens to dry longer is not going to make any difference. The emulsion will have reached equilibrium with the conditions around it. At that point, all you can do is wait for the weather to change before your screens will dry out any more (unless, you take steps to reduce the relative humidity in the area where your screens are drying).

Preferably you need a drying chamber in order to dry screens properly. At the least, you really need to have a separate, dedicated drying room. There is no point in putting a de-humidifier in the corner of a room and expecting to see a big improvement if doors (assuming you have them) are open constantly, and someone is using a pressure washer to de-haze screens in the next room.

The temperature in the drying chamber or dedicated drying room should be approximately 100°-110°F. Coated screens placed in this environment will dry faster, and will dry down to a much lower moisture content, as long as you use a fan to pull out the damp air and keep the relative humidity as low as possible.

Raising temperature is by far the most efficient way of reducing relative humidity and maximizing drying capacity. After all, how many hair dryers work on the principle of de-humidification?

Choosing An Exposure Unit

QUESTION

There are mercury-vapor, metal halide, fluorescent, incandescent quartz, and halogen lamps for exposure units each with its own wattage rating. What type is better? How do I compare lamp types and wattage in order to make an intelligent choice?

SOLUTION

You have to remember that stencil materials only respond to a narrow range of wavelengths. Namely those corresponding to UV, violet and blue light, together known as actinic light. This is the reason that we can work safely under yellow lights when coating and drying screens.

The best types of bulbs for exposing screens should therefore have a high actinic output. Incandescent quartz, white fluorescent tubes and halogen lamps spread their output evenly over a wide spectrum to give the appearance of white light. Most of the electrical power going in is not producing the type of light you need to shoot screens. Therefore any unit designed with these types of bulbs will have a low intensity and long exposure times.

High power mercury-vapor bulbs come in different versions, each of which emits a great deal of actinic light. The most effective bulbs for exposing screens contain doped mercury vapor, and there are two main types. The diazo or metal halide lamp, which contains gallium iodide, and the multi-spectrum or tri-metal halide, which, in addition to the gallium, also contains some iron salts.

These additional ingredients, along with the mercury vapor, boost the amount of useful actinic light (mainly violet/blue) which these bulbs emit.

The result is that you get about twice the output in comparison to standard mercury-vapor lamps. This means a higher intensity of light delivered to the stencil surface, and shorter exposure times.

Another measure of the efficiency of an exposure unit is the evenness of coverage. When exposing screens, depth of cure is very important. In other words, you have to harden the stencil evenly all the way through in order to avoid pinholes and premature breakdown.

To shorten exposure times, the temptation is to push the exposure unit closer to the screen. With larger vacuum frames, this leads to the formation of a “hot spot” in the center that gets overexposed and loses detail. However, with a rapid fall-off in intensity towards the edges of the frame, screens here can be underexposed and full of pinholes. A good reflector design can minimize or compensate for this effect. Once the lamp gets close enough to the screen, however, direct illumination from the bulb will always produce a hot spot.

The moral here is to make sure your exposure unit has enough kilowatts to enable you to pull the lamp back far enough to get even coverage, while keeping exposure times at a reasonable length.

On the subject of evenness of intensity, this is really the main claim to fame of exposure systems based on fluorescent tubes. Fluorescent tubes have been developed with a special phosphor coating on the inside of the glass that produces an actinic output around ten times greater than that of high output white fluorescents. The best type of tube only emits a very intense blue light of the optimum wavelength for exposing photostencils.

Typical intensity of this type of exposure unit is equivalent to a 6kW multi-spectrum at about 60" from the screen. Since 60" is the minimum recommended distance for exposing an image of around 40" x 40", this gives these fluorescent-based exposure units the edge in speed when it comes to exposing very large formats.

Determining Optimum Exposure

QUESTION
Why is optimum exposure important?

SOLUTION
Screen printing is dependent on optimum exposure time at the beginning of the process as a means of guaranteeing quality and performance at the end. Since probably 99% of incorrect exposure of direct photo-stencils is caused by underexposure, taking a little extra time and care during screen exposure can help you eliminate:

- Loss of fine detail during washout
- Excessive pinholes
- Scum leaking into and blocking the image areas
- Premature breakdown during printing or cleanup
- Difficult or impossible reclaimability

QUESTION
What is optimum exposure?

SOLUTION
Conventional and dual-cure emulsions contain a photosensitive ingredient, the diazo, that strongly absorbs blue and UV light. During exposure it decomposes, losing its absorption and causing the stencil to cross-link. This happens incrementally through the thickness of the stencil. In order for the emulsion in and behind the mesh to be properly cross-linked, it is necessary for the highly absorbing diazo in the emulsion in front of the mesh (i.e., closest to the light source) to be "bleached-out" by having a long enough exposure.

Unlike diazo, emulsions pure photopolymer products contain light-absorbing ingredients that react together to cause cross-linking. Although these products are photographically faster than diazo containing systems, the surface layers still need to be exposed first in order to properly cure deeper parts of the stencil. Remember, the cross-linked emulsion that encapsulates the mesh fibers gives direct stencils their superior durability, and this vital "inner" part of the stencil is most affected by underexposure.

As most of you know, underexposing stencils on purpose as a way of guaranteeing high resolution for fine-detail printing is a fairly common practice. While this may make a noticeable difference in resolution capability under adverse conditions (i.e., a low-resolution emulsion on white fabric), today's higher quality emulsions, when used on a correctly dyed fabric, are capable of resolving finer details than most inks are capable of printing. As long as you use high quality materials in the screen-making process, resolution should not be a factor in choosing exposure time. The optimum exposure time is always the point where the stencil has been fully cross-linked.

QUESTION
What affects optimum exposure?

SOLUTION
If you asked 100 screen makers to list the variables that affect exposure time, chances are they would all come up with basically the same answers. If, however, you asked them to arrange the items in order of importance, you would probably end up with 100 different versions. Basically, you should examine six different variables, listed in the approximate order that they affect screen exposure time:

- Intensity of light
- Distance from lamp to screen
- Mesh thickness
- Mesh color
- Coating thickness
- Emulsion type

QUESTION
How do I quickly and accurately predict optimum exposure time?

SOLUTION
While there are several options to predict optimum exposure, (i.e., the "color-change" method), there is a new method that eliminates lengthy and less accurate testing procedures that are difficult to interpret. By measuring the output of an exposure lamp in a narrow spectral band (i.e., violet/blue) where the photoemulsion is at its most sensitive, it is possible to predict what the required exposure time will be. Through extensive testing, manufacturers of stencil materials are able to compile the necessary data that relates the exposure dose required by a product when used under almost any condition. The quality control device used in this method is a digital radiometer.

Understanding Emulsions and Stencil Exposure

Exposure lamps of many types are used to make screens and they exist with a wide variety of spectral output, geometry of light delivery and power. The first thing that must be established is how much of the useful spectral output falls in a range that is used by the stencil material being exposed. Only a fraction of the rated input power of a lamp is converted into output with the correct wavelengths that can harden a stencil. This is known as actinic light, with wavelengths corresponding to blue, violet and ultraviolet. As can be seen in **Figure 1,** metal halide, multispectrum and certain specialty fluorescent tubes produce light very rich in these wavelengths. Other types of bulb are not suitable for high quality stencil production.

If you consider the light sensitive chemistry that is used in direct emulsions and capillary films, then you have to deal with two categories. Diazo and dual-cure types can be grouped together, as it is the diazo sensitizer that mainly determines the length of exposure and the degree of latitude. Photopolymer emulsions and films employ a different sensitizer referred to as SBQ that will react much faster than diazo when exposed with the correct type of lamp and will therefore be treated separately.

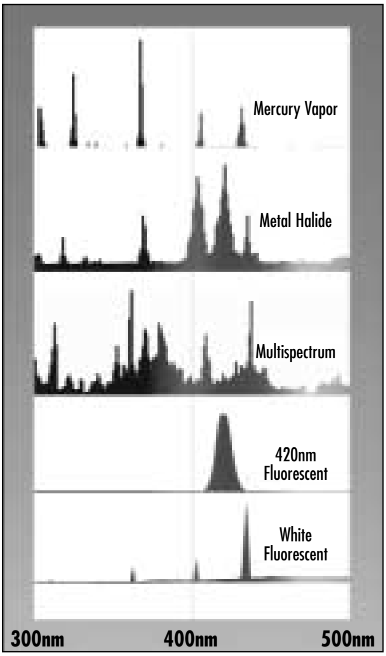

Figure 1

Figure 2 shows the light absorption spectrum for diazo sensitizer, with its peak in the UV at 373nm, overlaid on the output spectrum for a metal halide bulb. Also shown is the sensitivity curve for diazo. As can be seen, the peak in sensitivity corresponds to the tail of absorption where light is still absorbed, but less strongly and is therefore more penetrating. More on this later when we examine optimum exposures and degree of latitude, but in short, metal halide bulbs, sometimes referred to as diazo or gallium lamps with their peak output in the 390-420 nm violet/blue range are the best choice for optimizing exposure of diazo or dual-cure emulsions and films.

Figure 3 shows the analogous situation when photopolymer products are exposed. In this case the maximum of the absorption peak is at a shorter UV wavelength of 342nm. This shifts the peak of sensitivity into the 360-390 nm UV range where multispectrum bulbs, also referred to as trimetal halide or sometimes as iron lamps have their strongest output. The result is that multispectrum bulbs are the best choice for optimizing exposure of photopolymer emulsions and films.

This wavelength dependence of sensitivity of the two types of photosensitive systems results in a somewhat complicated relationship in their relative photographic speeds. As an example, take a photopolymer emulsion that requires only 20% of the exposure time of a diazo or dual-cure if used on an exposure system with a multispectrum bulb.

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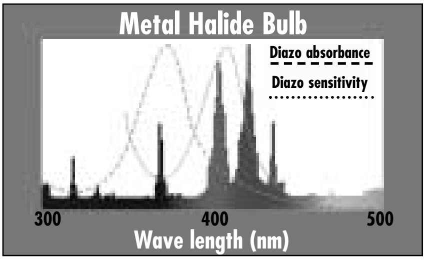

Figure 2

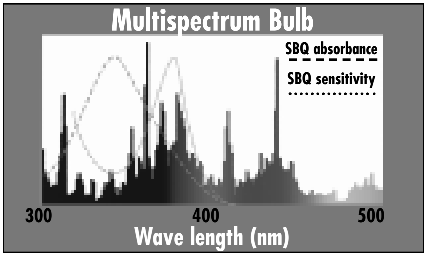

Figure 3

With a metal halide bulb, the photopolymer is less sensitive and slows down so that it now requires approximately 50% of the dual-cure exposure time. With 420nm fluorescent blue tubes, the longer wavelength output is so weakly absorbed by the photopolymer, that most of the light leaks right through and out the backside of the coating, with the result that the fast exposing photopolymer now requires about 75% of the dual-cure exposure time. White fluorescent tubes, with their very low UV output cause photopolymers to actually expose slower than most diazo or dual-cure products.

Don't be fooled by a lack of resolution, under these or any other circumstances, into thinking that a stencil is well exposed or even overexposed. Image resolution is affected by too many other factors to be used as a guide for determining exposure time. For instance, a poor vacuum caused by a leaking seal or rip in the blanket can kill resolution, even at a fraction of the correct exposure time. Similarly, incompatible combinations, such as photopolymer emulsion, coated on white mesh, and exposed with a fluorescent tube exposure system should be avoided. Combining any two of these variables can yield acceptable results, but all three things together is a recipe for very low-resolution stencils.

Optimum exposure time is only determined by depth of cure of the stencil. Depending on the printing application, the required thickness for a stencil, meaning mesh plus emulsion, can range from tens to hundreds of microns. In order to minimize pinholes, premature stencil breakdown, soapy scum during developing that bleeds, dries in and can block the image, or at least worsens reclaiming, the stencil has to be fully cured through its full thickness.

There are various techniques that can be used to determine optimum exposure and perhaps the most well known is the use of an exposure calculator. A typical example is shown in **Figure 4.** It utilizes a series of increasingly dark neutral density filters, overlaid on a repeating design, and allows multiple simultaneous exposures to be simulated, usually 100%, 70%, 50%, 33% and 25%.

After processing, the finished stencil has to be evaluated in a backlit environment by the color change method, and not for resolution. As can be seen in **Figure 5,** residual unused diazo shows up as a strong yellow undertone in the color of the stencil. The correct exposure is determined as the time taken for the diazo sensitizer, a yellow dye, to be completely bleached out. In a test situation, no yellow undertone should be seen on one of the middle sections of the calculator image. Once this has been achieved, the exposure factor for that part of the calculator is multiplied into the test exposure time, in order to find the optimum time. In an underexposure situation, the 100% exposure, or Factor 1, always looks correct, and the only thing this means is that

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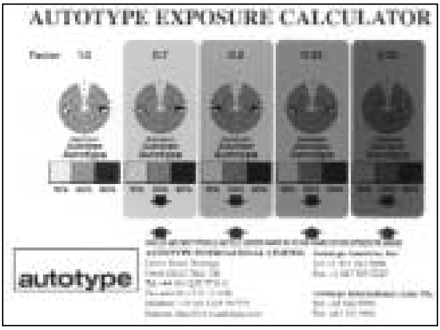

Figure 4

Figure 5

another test with double the exposure time is needed in order to move the first completely bleached out section into the middle of the calculator.

This type of exposure calculator works perfectly only for diazo emulsions. With dual-cures, there are often two separate color changes happening simultaneously, but with the extra dual-cure component color change being fainter but more persistent. The trick then becomes determining just when exactly did the diazo part stop changing color. With photopolymer stencils there is no color change, and although this type of exposure calculator may be useful for determining the degree of resolution available at several different exposure levels, it does not indicate the extent of cure.

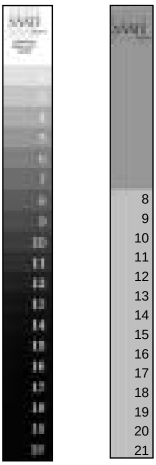

Figure 6 and 7

An alternative method is the use of a grayscale sensitivity guide, an example of which is shown in **Figure 6.**

In this case there are 21 continuous tone steps, with a density increase of 0.15 between successive steps. It is not a halftone dot pattern. Interestingly, this 0.15 density increment is the same as that employed for the series of filters used on the traditional exposure calculator mentioned previously. With longer exposure times, higher numbers of steps are successfully hardened into the finished stencil, and if used correctly, this technique can be can be used to determine the optimum exposure with only one test.

In almost all cases, a solid step 7 after development indicates a correctly exposed stencil, as is shown in **Figure 7.**

If the initial test yields only five steps, then the exposure needs to be doubled. Six steps require an increase of 40% in exposure time. Eight steps indicates an overexposure situation and possible loss of detail in the stencil, although no doubt fewer pinholes due to scratches, dust etc. Exposure time should be reduced to 70% of the original. Nine steps indicate a

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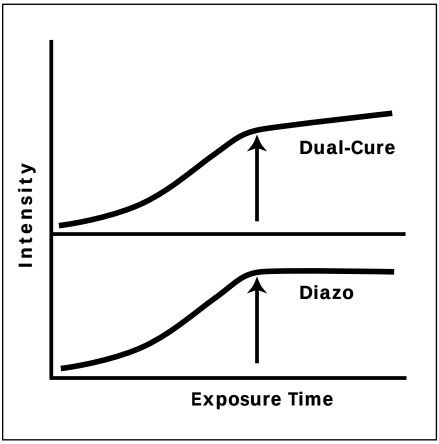

Figure 8

double overexposure. The biggest advantage of this method is that it can be used to control the degree of cure of any type of stencil, diazo, dual-cure or photopolymer.

The last recommended method does not use a test film at all, instead it employs a digital radiometer to determine the point at which all the sensitizer in the coating has been used up. It works like this, the photocell with a 365nm filter is placed in the vacuum frame, behind the emulsion coating, and the exposure is started. At the beginning, due to the extremely high absorbance of the sensitizer, no light is able to reach the photocell and the radiometer registers a reading of zero. During the exposure, as sensitizer is used up, an increasing amount of light is measured that gradually levels off. This information can be displayed in a graph, and the optimum exposure is indicated by a rollover in the gradient that shows the increase in light intensity measured behind the stencil. An example of this is shown in **Figure 8.**

Diazo emulsions finish flat, but dual-cures display a lesser and longer lived gradient, due to the additional photochemistry that also complicates evaluations during the color change method. Unfortunately, this method does not work with photopolymer products. This is due to high absorption even at the end of the exposure process caused by residual sensitizer. More on this later when we discuss post exposure effects.

Now comes the tough part. In the real world, most of the time, it is impossible to create a perfectly exposed screen like the example shown in **Figure 9.** The main reason is that light intensity is not even over the whole screen. With a typical point light source, that is best for reproducing good detail, unless the lamp is pulled back very far from the vacuum frame, then the intensity of the light in the corners of the screen will be significantly less than in the center. This leads to the cure profile shown in **Figure 10.** There are two

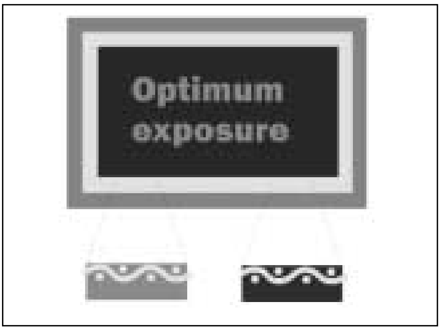

Figure 9

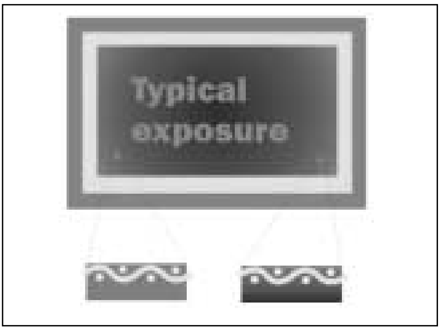

Figure 10

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scenarios shown here for the underexposed regions of the screen. In one case a bad bulb was used and the underexposure is concentrated at the foundation of the stencil where it adheres to the fabric. In the second case, although the stencil is equally underexposed, increased penetration by the light has resulted in a more even cure. One result of using a good bulb is a stencil with much wider exposure latitude that is evidenced by fewer pinholes and less scumming during development. It should be noted at this point, that when a doped bulb such as metal halide gets old and weak, then its spectrum gets closer to that of a mercury vapor bulb. The longer wavelength intensity drops, while the UV output remains relatively constant.

Fluorescent exposure systems do provide more uniform coverage for an even cure, but can lead to a compromise in detail, particularly with fine halftones. It is difficult for the film positive to cast a sharp shadow on the emulsion when lit from all angles. Care also has to be taken when exposing large screens with more than one exposure lamp to give wider coverage. The area of overlap between the lamps can suffer a slight loss of detail, usually in the vertical direction when the lamps are side by side. Highly magnified examples of this loss with fine detail on 305 mesh are shown in **Figure 11.**

Now if we can assume at this point that you have arrived in the comfort zone. Optimum exposures have been set for all of our mesh count/color/coating combinations. You have adequately exposed screens with all the detail you need, and none of the pinholes you don't. Now, how do you keep it that way? This is where our integrator comes in and compensates by increasing exposure time when the bulb gets old, or the power browns out. It is important to match the photocell filter to the sensitivity curve of emulsion, since a disproportionate amount of the stencil hardening that occurs is caused by those wavelengths that are most penetrating but still usefully absorbed. For instance, a narrow pass 365nm UV filter used with a metal halide bulb makes the integrator blind to fluctuations in the longer wavelength output that makes this bulb so effective in exposing diazo and dual-cure products.

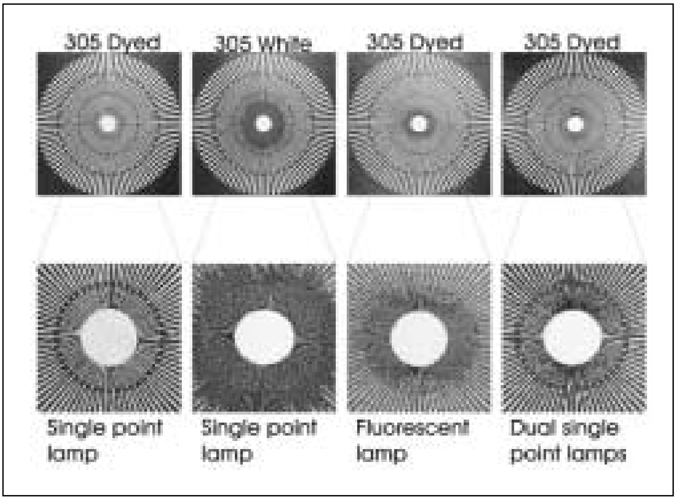

Figure 11

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Now we would like to mention the benefits of post exposure, which can be a useful technique for improving the resistance properties of a stencil. The benefits offered depend on the type of emulsion used, and can be summarized as follows.

Diazo emulsion or film - When a diazo emulsion is underexposed, the developed and dried stencil retains a yellow undercast from the unused diazo. This partially exposed diazo does not wash out of the stencil during developing as it has already reacted with, and become attached to, the polymers and resins that make up the stencil. So after drying it is possible to re-expose the screen, bleach out the remaining diazo and further cross-link the stencil to improve its solvent or water resistance. However, it should be noted that depending on the degree of initial under-exposure, the final stencil, although fully chemically cross-linked, may only be a thin skin stuck to the substrate side of the screen- mesh. It will not be as durable and resistant to pinholes as a correctly exposed stencil, where the screen-mesh has been physically encapsulated front and back with hardened emulsion.

There is absolutely no benefit to exposing a screen made with correctly exposed diazo emulsion, since all the diazo is already used up.

Dual-cure emulsion or film - When under-exposed, the situation is the same as for a diazo emulsion in that the unreacted diazo can further cross-link the stencil on post-exposure and improve its solvent and water resistance. However, the difference is that even correctly exposed dual-cures can benefit from post exposure. The reason is that the secondary cross-linking system can be made to polymerize further, even after all the diazo is used up. This usually improves only the solvent resistance, and can also result in easier reclaiming, since the hardened polymers and resins are affected less by ink and solvents.

Photopolymer emulsion and film – Photopolymer emulsions benefit most of all from post-exposure. Unlike diazo, which can be used with 100% efficiency if the exposure time is long enough, photopolymer molecules can be very stubborn. Only a proportion of them reacts very fast, and are responsible for the short exposure times of photopolymer emulsions. The rest of the photopolymer molecules are not aligned correctly and can cross-link only with difficulty. In this case, increasing the exposure time causes a loss of resolution and detail with little payback in terms of improved stencil durability. However, the potential of this unused photopolymer can be realized with a post-exposure. The reason is that during development, when the stencil is wet, some of the unreacted molecules will re-align and be available for crosslinking the second time around, thus resulting in improved solvent and water resistance. In some cases, the improvement in water resistance can be dramatic.

Finally, let's review the influence of the film positive on the exposure process, since image density and resolution of the film output device has a major bearing on stencil quality. High quality film positive output from an imagesetter will have a very low Dmin of around 0.05 (i.e. the film is clear and transmits more than 90%). Image areas will be a dense black, with a Dmax of 3 or more and will stop at least 99.9% of the light. Various other types of output device are now in common use, and at the other end of the scale is laser toner on vellum. A Dmin of 0.3 sounds good until you realize it blocks 50% of the available light and requires the exposure time to be doubled. Dmax is probably around 1 which stops 90% of the light but, unfortunately lets through the other 10%. The use of a

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solvent spray or heat treatment to fuse the toner can increase density to 2, but this is barely adequate for any fine detail as 1% of the light penetrates the stencil and this can be enough to compromise washout. Thermal imagesetter and inkjet output generally have very good densities and can be exposed without concern for burning through.

One point to remember is that anytime that anything other than crystal clear film is used to expose screens, then exposure calculators or grayscale sensitivity guides need to be placed behind a sheet of this material when making an exposure test. Otherwise the correct exposure time that is determined from the test will always be an underexposure with a real film. Photomicrographs of halftones produced on a selection of output devices are shown in **Figure 12,** to enable a comparison of dot quality.

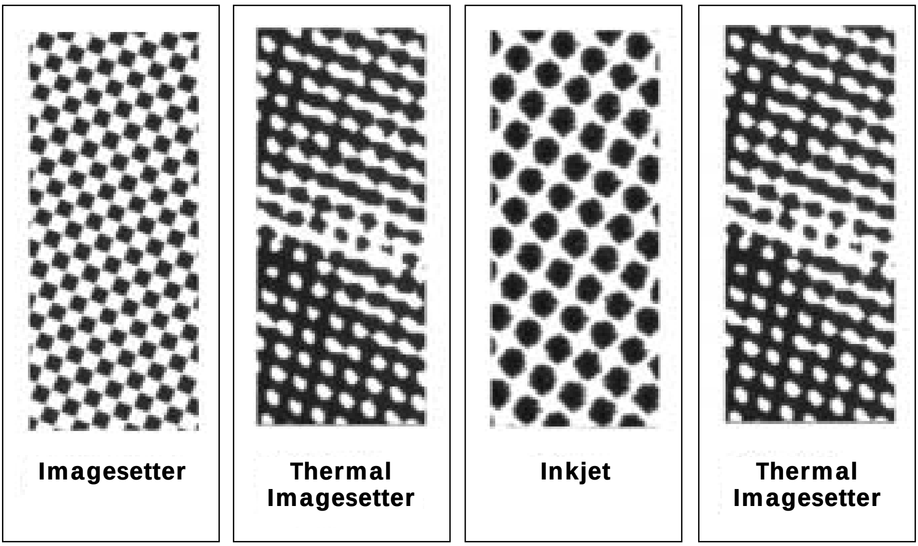


Figure 12

Using the Radiometer to Pinpoint 100% Correct Exposure Time

There is an option to measuring the intensity of your exposure lamp and using the chart of recommended exposure dose as a guideline to calculate exposure times. It is possible to use the radiometer as an analytical tool to pinpoint the 100% correct exposure time for any dual-cure or diazo emulsion on any mesh with your own particular coating method and exposure lamp.

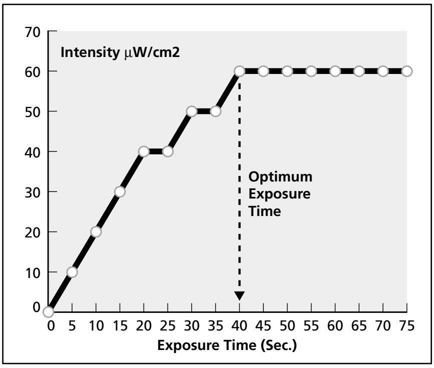
This is accomplished by placing the sensor from the radiometer behind the coated screen in an area where the emulsion is to be fully exposed. Then, by taking a series of measurements during the exposure, at say five-second intervals, it is possible to draw a graph that shows the intensity readings increasing rapidly as the exposure progresses. This happens as the diazo sensitizer is bleached out by actinic light from the exposure lamp, thereby allowing more light to penetrate through the back of the coating.

As optimum exposure is reached, and all the diazo has been used to harden the stencil, the intensity readings level off to a steady value and allow the absolute optimum exposure time to be determined for that particular combination of emulsion/mesh/coating method.

(See table and graph below.)

Grafic HU42 Photoemulsion Coated 2+3 on 420/PW31 Amber Hitech Mesh Exposed on 5KW Metal Halide at 40"

Exposure Measurements	Intensity Behind Screen
Start of Exposure	**0 Microwatts/cm2**
5 seconds	10 microwatts/cm2
10 seconds	20 microwatts/cm2
15 seconds	30 microwatts/cm2
20 seconds	40 microwatts/cm2
25 seconds	40 microwatts/cm2
30 seconds	50 microwatts/cm2
35 seconds	50 microwatts/cm2
40 seconds OPTIMUM	60 microwatts/cm2
45 seconds	60 microwatts/cm2
50 seconds	60 microwatts/cm2
55 seconds	60 microwatts/cm2
60 seconds	60 microwatts/cm2
65 seconds	60 microwatts/cm2
70 seconds	60 microwatts/cm2
75 seconds	60 microwatts/cm2



The Benefits Of Emulsion Stencil Post-Exposure

Post-exposure can be a useful technique for improving the resistance properties of a stencil. The benefits offered depend however on the type of emulsion used, and can be summarized as follows.

DIAZO EMULSION
When a diazo emulsion is under-exposed, the developed and dried stencil retains a yellow undercast from unused diazo. This is the basis for the color change method of determining optimum exposure. This partially exposed diazo does not wash out of the stencil during developing, as it has already reacted with and become attached to the polymers and resins that make up the stencil. After drying, it is possible to re-expose the screen, bleaching out the remaining diazo and further cross-linking the stencil to improve its solvent and water resistance. However, it should be noted that depending on the degree of initial under-exposure, the final stencil, although fully chemically cross-linked, may only be a thin skin stuck to the substrate side of the screen mesh. It will not be as durable and resistant to pinholes as a correctly exposed stencil where the screenmesh has been physically encapsulated, front and back, with hardened emulsion.

There is absolutely no benefit to post-exposing a screen made with correctly exposed diazo emulsion, since all the diazo is already used up.

DUAL-CURE EMULSION
When under-exposed, the situation is the same as for a diazo emulsion in that the unreacted diazo can further cross-link the stencil on post-exposure and improve its solvent and water resistance. However, the difference is that even correctly exposed dual-cure stencils can benefit from post-exposure. The reason is that the second cross-linking system, the part that makes an emulsion dual-cure, can be made to polymerize further, even after all the diazo is used up. This usually improves only the solvent resistance, and can also result in easier reclaiming.

PURE PHOTOPOLYMER EMULSION
Photopolymer emulsions benefit the most from post-exposure. Unlike diazo, which can be used with 100% efficiency if the exposure time is long enough, photopolymer molecules can be very stubborn. Only a proportion of them react very fast, and are responsible for the short exposure times of photopolymer emulsions. The rest of the photopolymer molecules are not aligned correctly and can cross-link only with difficulty. In this case, increasing the exposure time causes a loss of resolution and detail with little payback in terms of improved stencil durability. However, the potential of this unused photopolymer can be realized with a post-exposure. The reason is that during development, while the stencil is wet, some of the unreacted molecules will re-align and be available for cross-linking the second time around. Thus resulting in improved solvent and water resistance. In addition, the post-exposure can be made much longer than the original imaging exposure in order to maximize the cross-link density.

SAATI PRINT™

HANDBOOK

Quality Control & General Press Guidelines

Mesh Guidelines For Printing 4-Color Process

QUESTION

When printing four-color process, we know the importance of the angles used for the dots on the color separations. We also know we have to avoid certain combinations of mesh count with dots per inch on the positive in order to avoid moiré. What we are looking for are some guidelines on which mesh specification is most suitable for printing four-color process, and how fine a dot we should be able to hold.

GUIDELINES

The first thing to realize when printing four-color process is that screen tension is of paramount importance. Within this area, there are two factors that need to be controlled. Number one, it is important that all four screens are at the same tension level within one to two newtons, or you will have registration problems. If you increase off-contact in order to get better release of one screen out of the wet ink film, then the image on that screen prints bigger, causing misregistration.

Second, a minimum tension level of 20N is suggested. Less than this may not provide enough snap to cleanly release the stencil from the wet ink film once the squeegee passes. Failure to achieve this means that the screen drags in the wet ink and causes dot gain.

To address both these points, you will have maximum control over your screens if you use a Hitech (low-elongation) screen mesh. This type of mesh is designed to be more stable with respect to holding tension over time. This doesn't mean, however, that you should push the fabric to its limit by trying to achieve the highest possible tensions. It is more important to achieve consistent tension levels while working above the minimum requirement.

Our next recommendation is to use plain weave mesh. As a result of advances in weaving techniques, plain weave mesh is available in some of the finer mesh counts that traditionally were too difficult to produce, and so had to be woven with a twill, or even a double twill construction. The bottom line is that plain weave mesh interferes less with the way ink flows on the print, by virtue of its minimal contact area, or footprint, since only the crown of the mesh knuckles touch the substrate. Twill weave mesh will cause more problems with dot gain, and can even introduce moiré where you wouldn't expect it.

As far as how fine a dot you should be able to hold, that depends mainly on the mesh count you use, and on the thread diameter chosen. Minimum printable dot size, in microns, will then translate into a certain percentage of highlight dot, which depends on the halftone ruling (or number of dots per inch).

This minimum detail, that you can cleanly and consistently print, corresponds to openings in the stencil that are equal to one mesh opening plus one and a half thread diameters. Hence the relationship with mesh count and thread diameter.

If we choose a 305 plain weave mesh with 34 micron threads as an example, then so long as everything else is optimized (screen tension, ink, squeegee etc.), it should be possible to print down to 100 micron dots. This corresponds to 3% on a 45-line halftone, but only 9% on an 85-line. Detail smaller than this, for instance if your 85-line positive contains 7% dots, will always print as a moiré pattern.

An analogous situation exists in shadow areas of the print in order to ensure stencil durability during printing. Small spots of stencil clinging to the mesh, which you rely upon to block the flow of ink and distinguish between heavy mid to shadow tones, have to bridge between and adhere to a minimum of three mesh threads. Less than this, and shadow areas

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will quickly develop a spotty appearance, and again this may take the form of a moiré pattern. If we take the case of our 305.PW 34 mesh, the darkest tone on your positive that is safe to print corresponds to 94% on a 45-line halftone or 80% on an 85-line.

The following table compares the tonal range of some common halftone rulings that should be able to be printed through the mesh types shown.

If your specifications were that you have to be able to print a tonal range of 10% – 85%, then you can see from the chart that there is a minimum mesh count that you shouldn't drop below. For instance, an 85-line halftone would require the use of a 355 mesh or higher.

Higher mesh counts than the minimum can also be used if you want to print with a lower ink deposit, or you may be able to simply switch thread diameter. (This, however, enters us into a whole different story!)

MESH	**RANGE OF DOT PERCENT**		
Mesh Count/Weave/ Thread Diameter	**45 Line**	**65 Line**	**85 Line**
196.PW 55	6% – 86%	13% – 71%	21% – 51%
230.PW 48	4% – 90%	9% – 78%	15% – 63%
280.PW 40	3% – 93%	6% – 86%	11% – 75%
305.PW 34	3% – 94%	5% – 89%	9% – 80%
305.PW 31	2% – 96%	4% – 91%	7% – 85%
380.PW 31	2% – 97%	4% – 93%	6% – 88%

Take Control Of Your Screens For Printing 4-Color Process With UV Ink

PART 1 – INTRODUCTION

The complexities of screen printing four color process are further complicated when using UV cured ink, by extra demanding requirements in controlling ink deposit.

It's not enough to have to deal with the relationship of dots per inch with mesh count, or carefully selecting the angle of dots on each separation so you avoid not only mesh/dot moiré, but even dot to dot moiré between the overlaid colors. Now you also have to avoid the problems that can occur from printing halftones with an excessive ink deposit. Problems will occur when printing third and fourth colors if ink transfer from the screen to the substrate is severely affected by excessive ink deposit from the first two colors down. This is due to the high solids/low shrinkage characteristics of UV cured inks.

In terms of detail, highlight dots represent a major challenge. For instance, a 10% dot on an 85 line halftone is 0.004" across. To put this in perspective, if it were the size of a quarter, a 2" X 3/8" squeegee would be nine feet thick and forty two feet high. Therefore, in order to give ourselves the best chance of being able to successfully reproduce over seven thousand of these 0.004" dots per square inch of print, and to do it consistently with a carefully controlled ink deposit, we need to be in total control of our screen making process.

PART 2 – THE STENCIL

A screen-printing stencil performs four functions. Two are important for any type of screen-printing, since the stencil must first reproduce the image which is to be printed, and then be resistant to abrasion and chemical attack. The last two functions however are particularly important for high quality halftone printing with UV ink. The stencil will increase the quantity of ink which is printed, and is also responsible for controlling image accutance, more commonly referred to as print edge definition.

Photostencils fall into four main categories. The first is known as Indirect Film, where the stencil imaging and development process is carried out independently of the screen mesh. The stencil is applied to the mesh with gentle pressure and dried prior to removal of the backing film. Although capable of high quality reproduction, the thin edge of the finished stencil is very fragile and easily damaged and therefore unsuitable for long print runs, or for printing some difficult substrates.

The second type of stencil is known as Direct Film or Capillary Film. In this case, a much thicker layer of photographic emulsion is adhered to a wet screen mesh through capillary action. After drying and removal of the backing film, exposure and development produces a much stronger and more firmly adhered stencil than in the previous case, but still with the image quality associated with a film based product.

With the third type of stencil, known as Direct/Indirect, the film is laminated to the mesh with a layer of photographic emulsion instead of water. Once this sandwich has dried, processing is the same as for capillary film, but with the advantage that an even more firmly adhered and durable stencil results. The downside is that the stencil making process is more complicated, particularly in larger formats, and is also more costly.

That brings us to the last, and most commonly used type of stencil which is known as Direct Emulsion. In this case the mesh is coated with a light sensitive emulsion, which when dry is imaged and then developed in the same fashion as capillary film. This is by far the least expensive method in terms of material cost, and results in the most durable stencils. However it is also capable of producing much poorer print quality than any of the film based systems, unless the correct choices are made in terms of stencil materials and methods of processing, and bringing several variables under control.

The two most important stencil parameters which affect print quality, because of

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their influence on both ink deposit and print definition, are stencil profile and Rz value. **See Figure 1.**

Regardless of which type of stencil system is used, if fine halftones are to be reproduced, an important area where total control is required is during exposure. Producing a screen-printing stencil, even for use with the fine mesh counts used for printing UV cured inks, involves exposing

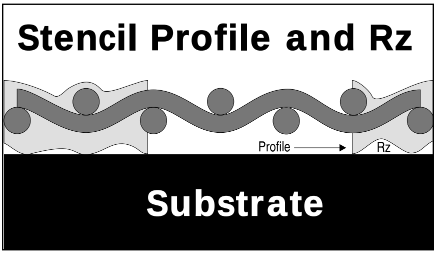

Figure 1

a coating which is very thick in comparison with those used for other photographic or imaging processes. Because of this, depth of cure through the stencil becomes a real issue. Poor through cure, or under-exposure, will cause one or more of the following problems. Loss of detail in shadow areas during development, excessive pinholes, scum leaking into and then blocking image areas, premature stencil breakdown during printing or clean-up, and last but not least difficult or impossible reclaim. Remember, we are talking expensive screen mesh here.

Overexposure in comparison will cause your dots to shrink, leading to moiré in the highlights and a lack of density in the print, and eventually loss of parts of your image altogether. In order to optimize the exposure process it is important that the equipment used is capable of producing high resolution stencils without the need to underexpose.A minimum of 20″ Hg of vacuum in the vacuum frame is required to ensure good enough contact between the artwork and emulsion during exposure. This prevents the undercutting of the image that occurs when light leaks under the positive. A good point light source fitted with a metal halide, or diazo, bulb is also recommended to produce optimum results, since there is a good match between the output of the bulb and the maximum sensitivity of most stencil materials. It is also important that the placement of the lamp, and the reflector design, is optimized so as to ensure even coverage of the image area during exposure. Even coverage is essential for accurate reproduction as well as stencil durability. If coverage is very uneven then the exposure latitude of the stencil material may be exceeded, and areas of the screen may be either under or over exposed, and sometimes even both on the same screen!

Another important variable related to exposure is drying. Both capillary film and direct emulsion coatings require very thorough drying prior to exposure, since any residual moisture present in the coating will react preferentially with the photosensitive resins which are supposed to harden the stencil. When you expose a damp screen you end up with a stencil which exhibits the symptoms of having been under-exposed, except that no improvement is seen on increasing exposure time.

Processing variables aside, the ideal stencil for printing halftones with UV ink should be thin and flat, and the parameters we need to control in order to achieve consistent, high quality results are stencil profile and Rz value. For optimum edge definition a stencil with a smooth flat underside is required, ie a low Rz value. This is because the stencil, as well as reproducing the image, also has to act like a gasket and prevent the ink from bleeding beyond the image area under pressure from the squeegee. The ragged edge of poorly defined dots can induce moiré, flattens contrast due to dot gain in the highlights, and loses any separation between midtone and shadow areas.

Minimizing stencil profile is important not only because of it's contribution of extra ink deposit, but also because of it's

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affect on durability. High profile stencils are more prone to breakdown in shadow areas, where the image depends upon small isolated spots of stencil clinging to the mesh. Mechanical abrasion, and sometimes loss of adhesion, causes heavy midtone and shadow areas to develop a spotty appearance which sometimes takes the form of a dark moiré pattern.

Ideal values are shown in **Figure 2,** stencil profile should normally be in the range of 2-10 microns, ideal Rz value is normally in the range of 4-8 microns. Smooth or polished sustrates require an Rz at the top end of the range to prevent cob-webbing or splattering of the ink due to static. For rough substrates, the lower the Rz the better.

Stencil Properties Required for Printing UV Ink
Stencil Should Be Thin and Flat
Stencil Profile : 2–10 microns
Stencil Rz Value : 4–8 microns

Figure 2

With capillary film, as long as the correct film thickness is selected, both stencil profile and Rz should automatically fall in the range of optimal values. **See Figure 3.** With direct emulsion the situation is not so simple. Simple wet on wet coating methods, which work so well for coarse and medium mesh counts, usually fail to transfer enough emulsion onto and through the fine mesh counts which are typically used for printing UV cured inks. The small percentage of open area, which is what restricts ink transfer, also prevents emulsion from passing through the mesh and building up on the print side of the screen. Even when using a high solids content emulsion, the shrinkage that occurs on drying may prevent us from achieving Rz values in the optimum range. **See Figure 4.**

Capillary Stencil, Profile & Rz On 380 PW 34

Stencil	Profile	Rz
15µ Capillary	2µ	3µ
20µ Capillary	8µ	2µ
15µ Capillary w/Emulsion	10µ	3µ

Figure 3

This problem is most evident with mesh types which are the best at minimizing ink deposit, particularly if you are using a sharp edge emulsion coater. In these circumstances, an additional coat of emulsion after drying can cut the Rz value in half, hopefully bringing it into the range we require, whilst adding barely a micron to the stencil profile. **See Figure 5.** Needless to say, maintaining constant stencil thickness and Rz values from screen to screen is all important if consistent print results are to be obtained, and if direct emulsion is the stencil of choice, then the use of an automatic coating machine is highly recommended to remove variables from the coating process.

Emulsion Stencil, Profile & Rz On 380 PW 34

Stencil	Profile	Rz
40% Solids 2+3 Sharp Edge Coater	2µ	12µ
50% Solids 2+3 Sharp Edge Coater	3µ	10µ
40% Solids 2+3 Dull Edge Coater	7µ	10µ
50% Solids 2+3 Dull Edge Coater	9µ	8µ

Figure 4

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Emulsion Stencil, Profile & Rz On 380 PW 34		
Stencil	**Profile**	**Rz**
40% Solids 2+3 Dry +2 Sharp Edge Coater	3μ	5μ
40% Solids 2+3 Dry +1 Dull Edge Coater	8μ	5μ

Figure 5

PART 3 – THE MESH

Before deciding which type of mesh to use, important consideration must be given to tensioning. Consistency of tension from screen to screen is of paramount importance when printing four-color process, and as with any type of multi-color printing, registration problems will occur if different tension screens are used. This is due to the higher off contact requirement for lower tension screens causing image enlargement.As a minimum, 20N of tension is suggested. Printing with low tension screens can cause poor ink release as the screen separates from the wet ink film, and dot gain may occur if the squeegee drags the stencil in the wet image. Increased off-contact can counteract this to a certain extent, but then the image will print too big, and the excessive squeegee pressure required will cause premature stencil wear.

Now screen-printing mesh comprises two parts, first threads, and you need enough of these to fully support the detail in the stencil, and secondly holes, and it is the size and number of these that controls your ink deposit. Normally mesh-count is the dominant factor in determining ink deposit. Above 305 mesh however, when we are dealing with the types of mesh designed for printing UV cured ink, ink deposit is no longer determined by mesh count. Thread diameter and the weaving construction itself become the over-riding considerations.

Fine mesh, which has traditionally been woven in a twill weave configuration, with the finest counts such as 460 being double twill, is now available in plain weave. In twill weave, the threads pass over one/under two, in double twill it's over two/under two. Plain weave mesh by comparison, with it's over one/under one configuration, has a much lower percentage open area since a thread is being inserted into every space in the weave. This not only shrinks the size of the mesh openings, but also results in a thinner fabric. The net result is that plain weave mesh prints less ink than twill weave mesh woven from the same thread, just what we need when printing four-color process with UV cured inks. If we take 380 mesh woven from 34 micron threads as an example, changing weave construction from twill to plain reduces ink deposit from 11 microns to 7 microns. **See Figure 6.**

Comparison of 380 Plain & Twill Weave			
	Fabric Thickness	**% Open Area**	**Ink Deposit**
380 PW 34	56μ	13%	7μ
380 TW 34	63μ	17%	11μ

Figure 6

Another area where plain weave mesh is capable of superior results is image definition. With twill weave mesh, the 'footprint' of the mesh on the substrate, ie the area where the surface of the threads contact, is quite substantial. In some circumstances it interferes with the flow of ink, and can cause poor print quality. With plain weave mesh since only the crown of the mesh knuckle contacts the substrate, interference with ink flow is kept to a minimum, and substantial improvements in print quality can generally be seen.

Plain weave mesh suitable for printing four-color process with UV cured ink is now available in 355, 380, 420 and 460 mesh counts. The 355 and 380 mesh is even available with a choice of

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34 or 31 micron thread diameters. The result of this is that by selecting the appropriate mesh, ink deposit can be varied from 7 microns, up to 15 microns, depending on your application or color-matching requirements, while still realizing the benefits of better print quality conferred by using plain weave fabric. **See Figure 7** for mesh specifications.

Comparison of 355, 380, 420 & 460 Plain Weave			
	Fabric Thickness	**% Open Area**	**Ink Deposit**
355 PW 31	48µ	28%	15µ
355 PW 34	55µ	16%	9µ
380 PW 31	48µ	20%	10µ
380 PW 34	56µ	13%	7µ
420 PW 31	49µ	17%	8µ
460 PW 27	43µ	18%	8µ

Figure 7

PART 4 – THE LIMITATIONS

When it comes to screen-printing halftones, the fact that we need the mesh to provide support for the detail in our image means that we are not going to be able to print a tonal range of 1% to 99%, **See Figure 8.**

At the highlight end of the tonal range, when the openings in our stencil become smaller than one mesh opening plus one and a half thread diameters, then they can be obscured by falling on or very near a thread. Trying to print dots this small invariably results in a moiré pattern, despite the fact that all the rules concerning angles and dots per inch have been observed. This limit of how fine a highlight we can satisfactorily print, depends mostly on mesh count, and to a lesser extent on thread diameter, but using 380 PW34 mesh as an example, the minimum stencil opening which will consistently print without moiré is 85 microns in diameter. This corresponds to a 4% dot for a 65 line halftone, 7% for 85 line, and 10% when we go to 100 line.

At the shadow end of the tonal range, the limit is reached when the small specks of stencil that have to block the flow of ink, and differentiate between the shadow tones, become smaller than two mesh openings plus one and a half thread diameters. Smaller than this, and they may adhere to only one or two threads and lack sufficient adhesion to withstand the rigors of processing. For instance, when trying to print a halftone which is too fine for the mesh in use, what usually happens is that the tonal range will collapse after the mid-tones. Once we exceed the detail carrying capacity of the mesh, we can print only one tonal value, and that is 100%. Again the mesh count, and to a lesser extent thread diameter are the important factors in determining the limit of what can be satisfactorily printed. In this case however, unlike the highlights where thinner threads are better, thicker threads extend the printable tonal range by offering improved adhesion. The upper limits for 65, 85 and 100 line halftones printed with 380 PW34 mesh correspond to 93%, 88% and 82% dots respectively.

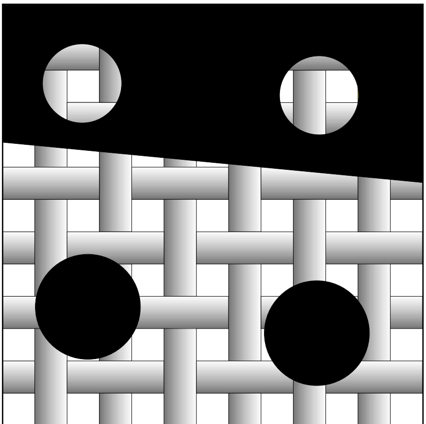

Figure 8

Minimum Size of Highlight Dot Is 1 Opening + 1.5 Threads

Minimum Size Of Shadow Dot Needs 2 Openings + 1.5 Threads For Stencil

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For more extensive information for 380 mesh. **See Figure 9.**

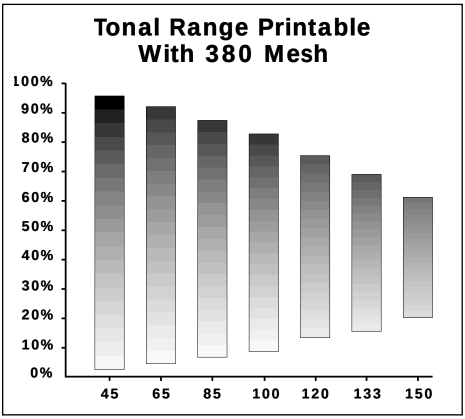

Figure 9

When selecting the optimum mesh type to use, both ink deposit and tonal range are usually taken into account. **See Figure 10,** which shows a comparison of both ink deposit, and minimum highlight dot which can be printed through plain weave mesh from 355 up to 460.

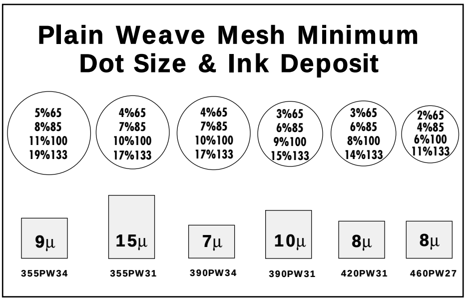

Figure 10

Two developments in methods of color separation, one established, and one very new, offer improved results for certain types of four color process printing with UV cured inks. The first method, which is widely used, is known as GCR or Gray Component Replacement. It enables a reduction in ink deposit in areas of the print where yellow, magenta and cyan all occur together. GCR will eliminate an equal amount of all three, which in some areas removes one of the colors entirely if 100% GCR is used. The missing gray is then restored with the final black printer. **See Figure 11.**

The second development, which is still being refined, is a new method of producing separations and is known as frequency modulated halftone, or stochastic screening, or random dot. The separations produced by this method are based upon randomly distributed, very small uniform sized dots, which simulate tones by increasing in packing density. This differs from conventional separations, where the dots are equally spaced and simulate tones by changing size. These random dot separations, because they have no angles, offer wider latitude in avoiding moiré, and are also capable of reproducing a wider range of tones. On the downside, they require an extremely high resolution stencil, and exquisite control over screen exposure if the image is not to be lost altogether. They may also be less suitable for reproducing certain types of artwork, as they sometimes suffer from a grainy appearance in highlight areas. However, this alternative technology offers promise in overcoming some of the problems some of the time, and may provide the opportunity to expand the use of screen-printing into otherwise difficult applications.

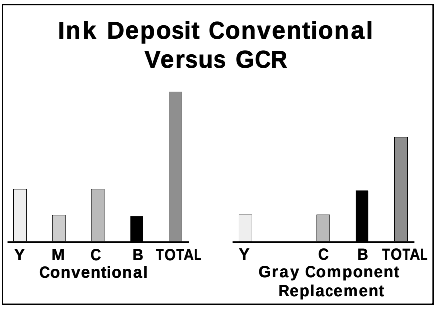

Figure 11

Controlling Off-Contact For Successful Printing

QUESTION

I have been told by many people that controlling off-contact is the key to success in printing. But how does it really affect my results?

SOLUTION

Off-contact is the distance between the substrate and the screen. This distance is needed to keep the screen from staying in contact with the substrate during printing and to control proper snap-off. While off-contact is not the only variable in the ocean of possible problems, it is a decent size fish as far as press variables go. The off-contact distance can affect your printing in any number of ways. Before you tackle this problem, however, you must make sure your screen has proper tension. Check your mesh manufacturer's tension recommendations. (Refer to "Using Proper Tensioning Techniques to Achieve the Desired Tension Level" Tech Tip on page 32.)

Assuming that your screens are at the proper tension levels, we will begin by covering the problems caused by too little off-contact. Poor release: if the fabric sticks to the substrate after the squeegee has passed, and the screen is lifted, you'll notice it takes a percentage of the ink with it and leaves mesh marks. You then have two options; either raise the off-contact, or slow down the print speed to accommodate this poor release. This is a common but incorrect solutions. If you make no adjustments, double images can appear, as well as image distortion. Not to mention the poor ink coverage that will result.

High off-contact, which is as common, causes a myriad of other problems. (Again, we will assume that your screen tension is correct.) Registration problems: these occur due to the excessive fabric deflection brought on by high off-contact. Inadequate squeegee pressure: As the off-contact distance increases, the squeegee pressure must be increased to force the fabric into contact with the substrate. This causes slower press speeds, image distortion, squeegee wear, and screen failure. Faster snap-off: Increasing the off-contact and squeegee pressure creates a faster snap-off. This can cause print defects such as bubbles, smearing, incomplete images, mis-registration and print voids.

Until recently, there were only a few ways to determine the off-contact distance. The most accurate method was by using a mechanical gauge. However, this process could take valuable time away from production, so it was usually abandoned and left to the operator to "eyeball" the distance. Now, the newly developed Positector 6000 off-contact gauge, with an easy-to-read digital display, can provide measurements automatically in minutes. Thus repeatability can be built into this print variable. Keep in mind, however, that this measurement provides the actual off-contact distance, not a determination of what is the proper off-contact distance. It is up to you, through testing, to determine the proper distance required for each press, screen tension, and format size. Having this tool to measure the distance, and maintain uniformity, makes the process more repeatable.

NOTE: a good rule of thumb is to have your screen as close as possible to the substrate, while maintaining the proper snap-off.

Choosing The Best Squeegee For Your Application

1. DUROMETER AND PRINTING EDGE (As Related To Ink Deposit)
The lower the durometer, and the less sharp the print edge, the more ink is deposited. The higher the durometer, and the sharper the print edge, the less ink is deposited. The more irregular or rougher the surface of the substrate is, the softer the durometer needed. (And vice versa.) To maximize solvent resistance, always use the hardest durometer that is practical for the particular job. The harder the squeegee, the more dense the urethane and therefore the stronger the chemical resistance.

2. COLOR CODING
Use color coding as a means of fast and easy identification of the correct squeegee durometer once you've established the hardness for your application.

3. PROFILE EDGE
a) Rectangular: applies to 95+ % of flat type printing.

b) "V" shape: applies to 90+ % of cylindrical printing. (Square is also used in some instances.)

c) Ballnose (rounded): used for more ink deposit — generally in some textile printing and industrial specialized heavy deposit applications. However, print edge sharpness is sacrificed. (Also used for direct/indirect stencil making and emulsion reinforcement of capillary film stencils.)

d) Dual-Durometer: used to optimize ink transfer efficiency and squeegee setting (pressure, angle, shear) via decreasing the blade's susceptibility to bending.

e) Composite: (similar to above) used for maximum rigidity.

4. LENGTH OF SQUEEGEE
Try to maximize the "free mesh area." This is the distance between the ends of the squeegee and the inside of the frame profile. This area is vital to provide the important flex and snap functions of the screen. It affects registration, print clarity, uniformity of ink deposit, and the life of the stencil, fabric and squeegee.

Care And Maintenance To Extend Squeegee Life

Even the most solvent and abrasion resistant squeegees, such as our Duralife™ brand, can benefit from some preventive maintenance to maximize longevity.

1. STORAGE
a) Store in a dry and generally cool area (50–85 degrees Fahrenheit).

b) Do not store coiled; lie flat to avoid distorting the print edge.

2. MAINTENANCE/ROTATION
For optimum squeegee life, rotate your blades in use as much as possible. All squeegees tend to swell and soften to some extent while in use. If they are given the opportunity to dry and return to their original state, they will last longer.

a) Establish a rotation schedule, based on the aggressiveness of your particular ink system, to allow the squeegee to "rest".

b) Inspect for signs of swelling – After approximately 2-4 hours of continuous printing with aggressive inks and solvents.

After approximately 6-8 hours of continuous printing with moderate to weak inks and solvents.

c) Change the squeegee at the first sign of swelling.

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d) Before resting squeegee, clean thoroughly with a solvent to remove any ink residue.

e) Never soak any squeegee in a solvent for an extended period; irreversible damage could result.

f) Depending on the durometer, and the ink and solvent aggressiveness, the squeegee may require a minimum of 12 to 48 hours of rest before re-use or re-sharpening. (Softer duros tend to absorb more and require longer recovery.)

3. SHARPENING

a) Before sharpening, the squeegee may require a 12 to 48-hour rest (depending on ink and solvent aggressiveness) to allow any solvents to evaporate.

b) A blade-cut type sharpener, versus a belt or grinding wheel sharpener, will yield a print-ready squeegee after just one pass.

c) Belt or grinding wheel sharpening is acceptable for most applications. It is best done in a two-step process using multiple passes (and limited pressure) that take off as little material as possible. This reduces heat buildup, which can melt the squeegee.

STEP 1. Coarse grit (60-120) to remove worn edge.

STEP 2. Fine grit (160-300) to create a sharp edge and a smooth, polished finish.

Duralife™ dual-durometer squeegees.

Duralife™ color-coded squeegees.

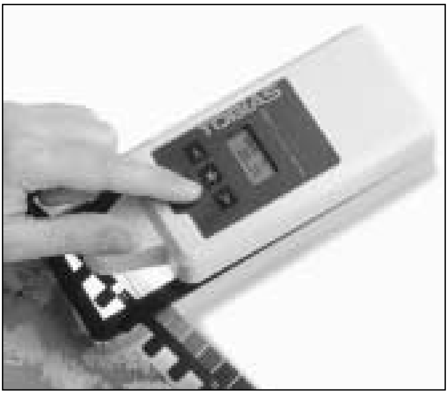
Duralife™ composite squeegees.

Guidelines To The Use Of A Transmission Densitometer For Screen Making

With the increasing use of artwork generated by laser printers, the need for checking the overall density of screen positives is more crucial. Vellum can particularly be a nightmare. Use of a transmission densitometer is the ideal quality control check for maintaining the density criteria required for optimum performance. For example, background density should be as low as possible. Preferably below 0.1, since a high background density will cause underexposure problems. Density of the image area should be as high as possible. Preferably above 3, to prevent fogging and poor washout.

A transmission densitometer, used in the % mode, is also ideal for checking the tonal range on halftone positives. It can be used as a QC measure on any films supplied, with attention paid to difficult areas, to determine if they fall within the appropriate range. screen-printing can not reproduce the 1%-99% dot range that can be held with offset printing. The range that can be reproduced successfully depends on the mesh count chosen, and the lines per inch count of the artwork. If everything else is perfect, such as tension, ink, squeegee, etc., then the following limits apply.

Mesh Count	65 Line	85 Line	100 Line	120 Line
305	5-89%	9-80%	13-71%	–
355	4-91%	7-85%	10-79%	14-70%
380	4-93%	6-88%	9-82%	13-75%
420	3-94%	5-90%	8-86%	11-80%
460	3-95%	5-92%	7-88%	9-85%



Use the TQ+™ Densitometer to maintain consistent film positives.

Guidelines To The Use Of A Reflection Densitometer For Screen-Printing

A reflection densitometer can be indispensable in checking your prints to quantify ink deposit, or solve ink mixing (pigment ratio) problems that may develop during long print runs and can cause shade differences. It can also be used to distinguish hue differences with ratio of CMYK values, and aid in color matching.

When printing four-color process, a reflection densitometer can be used to detect if any of the inks are under or over strength by quantifying problems with gray balance in 100% print areas. If calibrated on a 100% print area of a particular color, it can then detect the degree of dot gain (or loss) for that color by comparison with the transmission density readings from the positive. The standard procedure is to conduct these evaluations on step wedges that are printed with the image. For those printers who do not have the luxury of running test strips that can be trimmed off, an option is to settle on selected areas of the print that can be tested consistently.

This advanced, menu-driven IQ 150™ Reflection Densitometer provides the easiest means of density readings available.

Preventive Checklist
(For More Predictable & Repeatable Screen Making)

1. MESH SELECTION

- ❑ My mesh selection is based on the most suitable blend of tension/print characteristics for the degree of detail, length of run, ink deposit thickness and substrate surface.
- ❑ With my mesh count, I've chosen the proper thread diameter for my print requirements (higher tension, longer print life, better edge definition, 4-color process).
- ❑ The tension level I use corresponds to the mesh count/thread diameter (thinner = lower tension).
- ❑ I use a plain weave with a thin thread diameter, the combination recommended for optimum print detail.
- ❑ I have taken into consideration that twill weaves deposit more ink than plain weaves.

2. FRAME SELECTION & MESH TENSIONING

- ❑ I considered the format size and tension levels used when selecting the frame type, material and profile.
- ❑ When selecting my tensioning equipment, the determining factors were: my application, production capacity, tension levels, mesh type (polyester, nylon or stainless steel) and mesh count (coarse or fine).
- ❑ A tension meter, used correctly and optimally, is a standard part of my stretching process.
- ❑ I avoid taking the mesh to ultimate tension levels, as this sacrifices screen life.
- ❑ I use the most effective frame adhesive based on such factors as solvent and water resistance, production time requirements and odor.
- ❑ Production adheres to the mesh manufacturer's recommended tension levels.
- ❑ Correct tensioning procedures were established by reviewing the equipment manufacturer's recommendations, and by testing and documenting what works best in my operation.

3. MESH PREPARATION

- ❑ The screen making area is kept as isolated and clean as possible, as airborne dust and oils can cause pinholes and fisheyes.
- ❑ I degrease my screens from the first time they are used, and each time thereafter.
- ❑ Use of a wetting agent is standard, as it is critical for proper film application, and beneficial to uniform emulsion adhesion.
- ❑ A mesh prep with an abradant is used on "virgin" mesh (conventional synthetic monofilament).
- ❑ Household cleaners are never substituted for mesh degreasers or abradants, as they can damage the fabric, and contain oils/lanolin that can interfere with screen performance.
- ❑ Compressed air is not used to remove excess water from screens; it contains oils and water impurities that can cause fisheyes and pinholes.

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Preventive Checklist
(For More Predictable & Repeatable Screen Making)

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4. STENCIL SELECTION & APPLICATION

- ❑ My emulsion has been chosen based on ink type, solvent and water resistance, exposure time, artwork detail and durability.
- ❑ Tests have been run, and results documented, regarding what performs best in my particular operation.
- ❑ When coating manually, I use a screen coating trough designed for this purpose.
- ❑ Automatic coating has been evaluated in relation to production capacity, print requirements and the need for coating thickness consistency.
- ❑ The proper coating procedures are used, based on the manufacturer's recommendations and what works best in my process.
- ❑ I adjust coating sequence based on mesh specification.
- ❑ An emulsion thickness measuring device is used during stencil making.
- ❑ The proper emulsion thickness is matched to the resolution I need to hold.
- ❑ Stencil smoothness is matched to substrate smoothness using an Rz meter.

5. EXPOSURE

- ❑ Dried screens are checked for residual moisture before exposure by using a stencil moisture meter.
- ❑ My exposure system has been matched to my particular emulsion.
- ❑ The correct distance between my exposure system and vacuum frame is calculated and maintained.
- ❑ As a process control, an exposure calculator is used regularly and properly (and read accurately) on production screens.
- ❑ A radiometer is used to measure my exposure system's lamp uniformity and intensity.
- ❑ A radiometer is also used to help determine appropriate exposure times.
- ❑ The correct exposure time is determined specifically for each mesh count and emulsion type.

Regulatory Resources: Guidance Tools

As screen printers, you are called upon to handle regulated or hazardous materials. As a safety-conscious manufacturer/supplier, we've included the following additional resource suggestions to help you learn more about the safe use, disposal and transport of such materials. We've also included (on the next page) a step-by-step guide to waste classification and disposal. For more information or assistance, please call our Regulatory Affairs Coordinator at (847) 296-5090.

1. CODE OF FEDERAL REGULATIONS (CFR) & FEDERAL REGISTER

- Regulatory bible.
- Regulations as specified by the Occupational Safety & Health Administration (OSHA/29 CFR), Environmental Protection Agency (EPA/40 CFR) & Department of Transportation (DOT/49 CFR).
- The Federal Register is the most current listing of both proposed and finalized regulations.

SOURCE: Local library, safety supply companies, consulting companies, and the Government Printing Office Phone: (202) 783-3238 • www.access.gpo.gov

2. COMPLIANCE MANUALS

- Regulations are translated into layman's terms.
- Easier to understand & translate legal terminology.
- Step-by-step compliance.
- Some address one specific regulation.
- Offer update services.

SOURCE: Safety supply companies, consulting companies.

3. TRADE MAGAZINES ("OCCUPATIONAL HEALTH & SAFETY", "ENVIRONMENTAL PROTECTION")

- Discussions of regulations.
- Regulation updates (proposed & finalized).
- Informative articles written by environmental and safety professionals, industrial engineers, chemists, etc.
- Methods for waste treatment, recycling & water treatment are presented.

SOURCE: Stevens Publishing Company. Phone: (972) 687-6700 • www.stevenspublishing.com

4. MONTHLY NEWSLETTERS & BULLETINS

- Offer regulation updates and discussions of current "hot" topics.
- The Screen Printing & Graphic Imaging Association's (SGIA) monthly "Tabloid" includes a government affairs section.

SOURCE: Consulting companies, professional trade associations (Chemical Manufacturer's Association and SGIA) and trade magazines. Phone: (703) 385-1335. www.sgia.org

5. SEMINARS & COURSES

- Focus on specific agencies and specific regulations.
- Offer framework for understanding and complying with regulations.
- Speakers/instructors are often former employees of OSHA, EPA, or DOT, consultants, and/or industry experts.
- Offer certification programs.

SOURCE: Consulting companies, professional trade associations (Chemical Manufacturer's Association and SGIA) and trade magazines.

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Regulatory Resources: Guidance Tools

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6. CONSULTING COMPANIES

- Offer advisory legal hotlines for compliance guidance.
- Will perform safety and environmental audits of your facility.
- Will assist in completing & filing complicated regulatory reports, permits, waste documentation, etc.

SOURCE: Company direct, Yellow Pages, industrial directories.

7. LOCAL & LAW LIBRARIES

- To obtain copies of city/county codes, state/federal regulations (CFR, Federal Register).
- Research specific areas (like wastewater treatment technology, etc.).

SOURCE: Telephone directory/Yellow Pages, local business or community directory, city agencies.

8. MANUFACTURERS/SUPPLIERS

- To obtain/interpret Material Safety Data Sheets (MSDS).
- To obtain technical information regarding product use, handling and disposal.
- Usually offer compliance assistance/guidance.
- Often employ a regulatory/compliance officer and, in some cases, an entire staff.

SOURCE: Product labels, product literature, MSDS, trade and/or industrial directories.

9. MATERIAL SAFETY DATA SHEETS (MSDS)

- Provide an excellent quick reference source.
- Provide chemical composition information; usually disclose hazardous ingredients.
- Often provide OSHA, EPA and DOT information on a single document.
- Sometimes offer specific methods for safe handling, pollution control and waste treatment.

SOURCE: Manufacturer, supplier, distributor.

10. LOCAL AUTHORITIES

- Local OSHA/EPA/DOT offices, water reclamation district (Publicly Owned Treatment Works/POTW), county health department.
- To obtain copies of regulations.
- To obtain compliance assistance.
- Offer 800# hotlines for regulation updates and interpretation.

SOURCE: Local telephone directory, local business or community directory, government agencies, SGIA, manufacturers/suppliers.

Step-By-Step Guide To Waste Classification & Disposal

I. IDENTIFY THE WASTE AND/OR ITS CONSTITUENTS.

A. Consult resources.

1. Review Material Safety Data Sheets (MSDS).

2. Contact the manufacturer.

a) To obtain assistance interpreting the MSDS.
b) To obtain component information/ingredient disclosure.

II. CLASSIFY THE WASTE (HAZARDOUS/NONHAZARDOUS).

A. Consult resources.

1. Review MSDS for hazardous ingredients (usually disclosed down to 1%; carcinogens/toxins down to 0.1%).

2. Consult the Code of Federal Regulations (CFR)/compliance manuals for hazard class definitions and lists of hazardous/regulated chemicals.

a) Do the chemical constituents meet the definition of "hazardous", as specified by either the Occupational Safety & Health Administration (OSHA), Department of Transportation (DOT) or the Environmental Protection Agency (EPA)?
b) Are the chemical constituents specifically listed/regulated by any of the above-mentioned agencies?
c) Are the chemical constituents any of the following?
– Volatile Organic Compounds (VOCs)/Federal Clean Air Act?
– Ozone Depleting Chemicals (ODCs)/Federal Clean Air Act?
– Hazardous Air Pollutants/Federal Clean Air Act
– Toxic as per Superfund Amendments & Re-authorization Act of 1986 (SARA Title III)?
– Priority Pollutants as per the National Pollutant Discharge Elimination System (NPDES)/Clean Water Act?
d) Are any of the chemical constituents either listed or characteristic hazardous wastes, as specified by the Hazardous & Solid Waste Amendments (HSWA)/ Resource Conservation & Recovery Act of 1976 (RCRA) in Title 40 of the Code of Federal Regulations (40 CFR)?

3. Review state and local authorities' regulations.

a) Are the chemical constituents regulated under a state hazardous/solid waste program?
b) Are the chemical constituents regulated under a state/local air quality program?
c) Are the chemical constituents regulated/prohibited from discharge by the local Publicly Owned Treatment Works (POTW/sewer authority)?

4. If waste is hazardous, determine its appropriate class/characteristic (ie. ignitable, corrosive, reactive or toxic).

III. DETAIL INFORMATION ON THE PRINTING/RECLAIMING OPERATIONS AND THE QUANTITIES OF WASTE INVOLVED.

A. How is the chemical (pollutant) being used in the operation?

B. If the waste is a mixture, what percentage is hazardous?

C. Is the waste (or its constituents) being emitted from your facility?
If yes, then: Review state/local air permitting requirements.

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Step-By-Step Guide To
Waste Classification & Disposal

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D. Does the waste (or its constituents) enter your effluent (waste stream)? If yes, then:

1. What is the concentration of the pollutant at the point of introduction?

2. What is the water usage/consumption on a typical production day?

3. Is the effluent being substantially diluted by other waste streams?

4. What is the probable concentration of the pollutant in the exiting effluent?

5. Is the waste (or its constituents) either acidic or alkaline in nature?

6. Is the waste (or pollutant) known to be biodegradable?

7. What are the Biochemical Oxygen Demand (BOD)/Chemical Oxygen Demand (COD) values of the constituents?

IV. CONDUCT (RECOMMENDED) WASTE CHARACTERIZATION AND/OR EFFLUENT SAMPLING/TESTING.

V. MAKE GENERAL ASSESSMENT BASED ON THE ABOVE INFORMATION.

A. If waste characterization and/or effluent testing can be done, then it's advisable to wait for the results before making a determination.

B. If the waste involved is, in fact, hazardous, consider switching to safer, non-hazardous alternatives, if possible. You may be able to significantly reduce, or eliminate, your hazardous waste inventory and subsequent pollutants.

C. If very large quantities of waste are involved, then waste hauling may be recommended (whether the waste is hazardous or not).

D. If a generally accepted method of recycling/pretreatment is plausible for the particular waste, then it should be considered at this point.

E. Research potential recycling/pretreatment strategies. (Examples: distillation, filtration, neutralization, aeration, oil/water separation, toxics precipitation.) These recovery/pretreatment techniques can sometimes allow for recycling of solvents and/or cleaning up polluted waste streams.

F. Gather information from vendors regarding available systems, operation/maintenance of equipment and associated costs. Weigh the pros and cons of "in-house" treatment versus waste hauling.

G. If "in-house" treatment is not viable, and/or large quantities of "known" hazardous waste are being generated, then it is recommended that the printer safely collect and retain the waste for haulage. Manufacturers can offer guidance in regard to handling of waste associated with their products.

Conversion Guides

To Convert From	To	Multiply By
Bar	Kilogram per square centimeter	1.01977
	Pascal	100000.0
	Pound per square foot	2088.576
	Pound per square inch	14.504
British Thermal Unit	Foot-pound	778.6
	Joule	1055.0
	Kilocalorie	0.252
	Kilogram-force meter	107.6
	Kilowatt hour	0.000293
British Thermal Unit Per Second	Horsepower	1.415
	Joule per second	1055.0
	Kilocalorie per second	0.252
	Kilowatt	1.055
Centigram	Dram	0.00564
	Gram	0.01
	Kilogram	0.00001
	Ounce	0.00035
	Pound	0.00002
Centimeter	Foot	0.0328
	Inch	0.3937
	Meter	0.01
	Millimeter	10.0
	Yard	0.0109
Centipoise	Gram-force second/square centimeter	0.0000102
	Kilogram per meter hour	3.6
	Poise	0.01
	Pound per foot hour	2.419
	Pound per foot second	0.000672
	Pound per inch second	0.000056
	Pound-force second per square foot	0.0000209
	Pound-force second per square inch	0.000000145
Cubic Centimeter	Cubic foot	0.000035
	Cubic inch	0.06102
	Cubic meter	0.000001
	Cubic yard	0.0000013
	Fluid ounce	0.03382
	Liter	0.001
	Milliliter	1.0
Cubic Foot	Cubic centimeter	28317.0
	Cubic inch	1728.0
	Cubic meter	0.0283
	Cubic yard	0.037
	Gallon	7.48

Conversion Guides (cont'd.)

To Convert From	To	Multiply By
Cubic Inch	Cubic centimeter	16.387
	Cubic foot	0.00058
	Cubic meter	0.000016
	Cubic yard	0.000021
	Fluid ounce (Imp.)	0.57677
	Fluid ounce (U.S.)	0.5541
	Gallon (Imp.)	0.00361
	Gallon (U.S.)	0.00433
	Liter	0.01639
	Milliliter	16.387
	Quart (Imp.)	0.01442
	Quart (U.S.)	0.01732
Cubic Meter	Cubic centimeter	1000000.0
	Cubic foot	35.3145
	Cubic inch	61023.5
	Cubic yard	1.3079
	Gallon	264.2
	Liter	1000.0
Cubic Yard	Cubic centimeter	764559.0
	Cubic foot	27.0
	Cubic inch	46656.0
	Cubic meter	0.7648
Fluid Ounce – Imperial	Cubic inch	1.7338
	Fluid ounce (U.S.)	0.9607
	Gallon (Imp.)	0.00625
	Gallon (U.S.)	0.0075
	Liter	0.02841
	Milliliter	28.4132
	Quart (Imp.)	0.025
	Quart (U.S.)	0.03
Fluid Ounce – U.S.	Cubic centimeter	29.57286
	Cubic inch	1.80469
	Fluid ounce (Imp.)	1.0408
	Gallon (Imp.)	0.0065
	Gallon (U.S.)	0.0078
	Liter	0.02957
	Milliliter	29.57286
	Quart (Imp.)	0.026
	Quart (U.S.)	0.03125

Conversion Guides (cont'd.)

To Convert From	To	Multiply By
Foot	Centimeter	30.48
	Inch	12.0
	Meter	0.305
	Milliliter	304.8
	Yard	0.333
Foot – Pound	British thermal unit	0.00129
	Joule	1.356
	Kilocalorie	0.000324
	Kilogram – force meter	0.1383
	Kilowatt hour	0.000000376
Gallon – Imperial	Cubic inch	277.42
	Fluid ounce (Imp.)	160.0
	Fluid ounce (U.S.)	153.723
	Gallon (U.S.)	1.201
	Liter	4.546
	Milliliter	4546.112
	Quart (Imp.)	4.0
	Quart (U.S.)	4.804
Gallon – U.S.	Cubic foot	0.1337
	Cubic inch	230.947
	Cubic meter	0.00379
	Fluid ounce (Imp.)	133.2334
	Fluid ounce (U.S.)	128.0
	Gallon (Imp.)	0.8327
	Liter	3.7853
	Milliliter	3785.327
	Pounds of water	8.40336
	Quart (Imp.)	3.33
	Quart (U.S.)	4.0
Gram	Centigram	100.0
	Dram	0.5644
	Kilogram	0.001
	Ounce	0.0353
	Pound	0.0022
Grams Per Liter	Ounces per gallon	0.13353
	Pounds per gallon	0.008345

Conversion Guides (cont'd.)

To Convert From	To	Multiply By
Gram-Force Second/ Square Centimeter	Centipoise	98070.0
	Kilogram per meter hour	353000.0
	Poise	980.7
	Pound per foot hour	237200.0
	Pound per foot second	65.9
	Pound per inch second	5.492
	Pound-force second per square foot	2.048
	Pound-force second per square inch	0.01422
Horsepower	British thermal unit per second	0.7073
	Joule per second	745.7
	Kilocalorie per second	0.1782
	Kilowatt	0.7457
Inch	Centimeter	2.54
	Foot	0.08333
	Meter	0.0254
	Millimeter	25.4
	Mil	1000.0
	Yard	0.02777
Joule	British Thermal Unit	0.00095
	Foot-pound	0.7376
	Kilocalorie	0.00024
	Kilogram-force meter	0.102
	Kilowatt hour	0.000000278
Joule Per Second	British thermal unit per second	0.00095
	Horsepower	0.00134
	Kilocalorie per second	0.00024
	Kilowatt	0.001
	Watt	1.0
Kilocalorie	British thermal unit	3.97
	Foot-pound	3087.0
	Joule	4187.0
	Kilogram-force meter	426.9
	Kilowatt hour	0.00116
Kilocalorie Per Second	British thermal unit per second	3.968
	Horsepower	5.614
	Joule per second	4187.0
	Kilowatt	4.187
Kilogram	Centigram	100000.0
	Dram	564.383
	Gram	1000.0
	Ounce	35.274
	Pound	2.205

Conversion Guides (cont'd.)

To Convert From	To	Multiply By
Kilogram Per Meter Hour	Centipoise	0.2778
	Gram-force second/square centimeter	0.0002833
	Poise	0.002778
	Pound per foot hour	0.672
	Pound per foot second	0.000187
	Pound per inch second	0.0000155
	Pound-force second per square foot	0.0000058
	Pound-force second per square inch	0.00000004
Kilogram Per Square Centimeter	Bar	0.98067
	Pascal	98066.5
	Pound per square foot	2048.112
	Pound per square inch	14.223
Kilogram-Force Meter	British thermal unit	0.0093
	Foot-pound	7.233
	Joule	9.807
	Kilocalorie	0.00234
	Kilowatt	0.00000272
Kilowatt	British thermal unit per second	0.9484
	Horsepower	1.341
	Joule per second	1000.0
	Kilocalorie per second	0.239
Kilowatt Hour	British thermal unit	3413.0
	Foot-pound	2655000.0
	Joule	3597000.0
	Kilocalorie	860.0
	Kilogram-force meter	367100.0
Liter	Cubic centimeter	1000.0
	Cubic inch	61.02
	Cubic meter	0.001
	Fluid ounce (Imp.)	35.195
	Fluid ounce (U.S.)	33.8148
	Gallon (Imp.)	0.22
	Gallon (U.S.)	0.264
	Milliliter	1000.0
	Quart (Imp.)	0.88
	Quart (U.S.)	1.0567
Meter	Centimeter	100.0
	Foot	3.281
	Inch	39.37
	Millimeter	1000.0
	Yard	1.094
Micron	Centimeter	0.0001
	Mil	0.03937

Conversion Guides (cont'd.)

To Convert From	To	Multiply By
Mil	Inch	0.001
	Micron	25.4
Milliliter	Cubic inch	0.06102
	Fluid ounce (Imp.)	0.0352
	Fluid ounce (U.S.)	0.0338
	Gallon (Imp.)	0.00022
	Gallon (U.S.)	0.000264
	Liter	0.001
	Quart (Imp.)	0.00088
	Quart (U.S.)	0.00106
Millimeter	Centimeter	0.10
	Foot	0.00328
	Inch	0.03937
	Meter	0.001
	Yard	0.00109
Ounce	Centigram	2834.9
	Dram	16.0
	Gram	28.3495
	Kilogram	0.0284
	Pound	0.0625
Ounces Per Gallon	Grams per liter	7.489
Pascal	Bar	0.00001
	Kilogram per square centimeter	0.0000102
	Newton per square meter	1.0
	Pound per square foot	0.0209
	Pound per square inch	0.000145
Poise	Centipoise	100.0
	Gram-force second/square centimeter	0.00102
	Kilogram per meter hour	360.0
	Pound per foot hour	241.9
	Pound per foot second	0.0672
	Pound per inch second	0.0056
	Pound-force second per square foot	0.00209
	Pound-force second per square inch	0.0000145
Pound	Centigram	45359.2
	Dram	256.0
	Gram	453.5924
	Kilogram	0.4536
	Ounce	16.0
Pounds Per Gallon	grams per liter	119.832

Conversion Guides (cont'd.)

To Convert From	To	Multiply By
Pound Per Foot Hour	Centipoise	0.4134
	Gram-force second/square centimeter	0.0000042
	Kilogram per meter hour	1.488
	Poise	0.004134
	Pound per foot second	0.000278
	Pound per inch second	0.0000231
	Pound-force second per square foot	0.00000863
	Pound-force second per square inch	0.00000006
Pound Per Foot Second	Centipoise	1488.0
	Gram-force second/square centimeter	0.01518
	Kilogram per meter hour	5357.0
	Poise	14.88
	Pound per foot hour	3600.0
	Pound per inch second	0.08333
	Pound-force second per square foot	0.032
	Pound-force second per square inch	0.000216
Pound Per Inch Second	Centipoise	17860.0
	Gram-force second/square centimeter	0.1821
	Kilogram per meter hour	64290.0
	Poise	178.6
	Pound per foot hour	43200.0
	Pound per foot second	12.0
	Pound-force second per square foot	0.373
	Pound-force second per square inch	0.0026
Pound Per Square Foot (PSF)	Bar	0.00048
	Kilogram per square centimeter	0.00049
	Pascal	47.88
	Pound per square inch	0.00694
Pound Per Square Inch (PSI)	Bar	0.06895
	Kilogram per square centimeter	0.07031
	Pascal	6894.8
	Pound per square foot	144.0

Conversion Guides (cont'd.)

To Convert From	To	Multiply By
Pound-Force Second Per Square Foot	Centipoise	47880.0
	Gram-force second/square centimeter	0.4882
	Kilogram per meter hour	172400.0
	Poise	478.8
	Pound per foot hour	115800.0
	Pound per foot second	32.17
	Pound per inch second	2.681
	Pound-force second per square inch	0.00694
Pound-Force Second Per Square Inch	Centipoise	6895000.0
	Gram-force second/square centimeter	70.31
	Kilogram per meter hour	24820000.0
	Poise	68950.0
	Pound per foot hour	16680000.0
	Pound per foot second	4633.0
	Pound per inch second	386.1
	Pound-force second per square foot	144.0
Quart (Imperial)	Cubic inch	69.355
	Fluid ounce (Imp.)	40.0
	Fluid ounce (U.S.)	38.43
	Gallon (Imp.)	0.25
	Gallon (U.S.)	0.3002
	Liter	1.1365
	Milliliter	1136.528
	Quart (U.S.)	1.201
Quart (U.S.)	Cubic inch	57.75
	Fluid ounce (Imp.)	33.308
	Fluid ounce (U.S.)	32.0
	Gallon (Imp.)	0.2082
	Gallon (U.S.)	0.25
	Liter	0.9463
	Milliliter	946.3316
	Quart (Imp.)	0.8327
Square Centimeter	Square foot	0.00108
	Square inch	0.15502
	Square meter	0.0001
	Square yard	0.00012
Square Foot	Square centimeter	929.0304
	Square inch	144.0
	Square meter	0.0929
	Square yard	0.1111

Conversion Guides (cont'd.)

To Convert From	To	Multiply By
Square Inch	Square centimeter	6.45162
	Square foot	0.00694
	Square meter	0.00065
	Square yard	0.00077
Square Meter	Square centimeter	10000.0
	Square foot	10.764
	Square inch	1550.388
	Square yard	1.196
Square Yard	Square centimeter	8361.274
	Square foot	9.0
	Square inch	1296.0
	Square meter	0.836
Threads Per Centimeter	Threads per inch	2.54
Threads Per inch	Threads per centimeter	0.394
Yard	Centimeter	91.44
	Foot	3.0
	Inch	36.0
	Meter	0.915
	Millimeter	914.4

Conversion Guides (cont'd.)

TEMPERATURE CONVERSION EQUATIONS

Fahrenheit to Celsius	(°F - 32) .5555	=	°C
Celsius to Fahrenheit	(°C x 1.8) + 32	=	°F
Fahrenheit to Kelvin	(°F + 459.67) .5555	=	°K
Kelvin to Fahrenheit	(°K x 1.8) - 459.67	=	°F
Celsius to Kelvin	°C + 273.15	=	°K
Kelvin to Celsius	°K - 273.15	=	°C

VOLUMETRIC CONVERSION FORMULAS

Imperial Gallon	x 1.2	=	U.S. Gallon
Pounds of Water	x 0.119	=	Gallons
Cubic Feet	x 7.48	=	Gallons
Cubic Inches	x 0.00433	=	Gallons
Cubic Meters	x 264.2	=	Gallons
Cubic Meters	x 1000	=	Liters
Cubic cm	(cm^3)	=	Milliliter
Cubic cm	x 0.0338	=	Fluid Ounces
Fluid Ounces	x 29.57	=	Cubic cm
Liters	x 1000	=	Cubic cm
Grams/Liter	x 0.008345	=	Pounds/Gallon
Grams/Liter	x 0.1335	=	Ounces/Gallon
Pounds/Gallon	x 119.8	=	Grams/Liter
Ounces/Gallon	x 7.489	=	Grams/Liter

Conversion Guides (cont'd.)

UNITS OF CAPACITY – U.S. Liquid Measure

Unit	Fluid Ounce (fl oz)	Quart (qt)	Gallon (ga)	Milliliter (ml)	Liter (l)	Cubic Inch (in^3)
Fl Ozs	1	32.0	128.0	0.0338	33.8148	0.5541
Quarts	0.03125	1	4.0	0.00106	1.0567	0.01732
Gallons	0.0078	0.25	1	0.000264	0.264	0.00433
Mls	29.57286	946.3316	3785.327	1	1000.0	16.387
Liters	0.02957	0.9463	3.7853	0.001	1	0.01639
$Inches^3$	1.80469	57.75	231.0	0.06102	61.02	1

UNITS OF CAPACITY – Imperial Liquid Measure

Unit	Fluid Ounce (fl oz)	Quart (qt)	Gallon (ga)	Milliliter (ml)	Liter (l)	Cubic Inch (in^3)
Fl Ozs	1	40.0	160.0	0.0352	35.195	0.57677
Quarts	0.025	1	4.0	0.00088	0.88	0.01442
Gallons	0.00625	0.25	1	0.00022	0.22	0.00361
Mls	28.4132	1136.528	4546.112	1	1000.0	16.387
Liters	0.02841	1.1365	4.546	0.001	1	0.01639
$Inches^3$	1.7338	69.355	277.42	0.06102	61.02	1

UNITS OF AREA

Unit	Square Inch (in^2)	Square Foot (ft^2)	Square Yard (yd^2)	Square Centimeter (cm^2)	Square Meter (m^2)
$Inches^2$	1	144.0	1296.0	0.15502	1550.388
$Feet^2$	0.00694	1	9.0	0.00108	10.764
$Yards^2$	0.00077	0.1111	1	0.00012	1.196
Cms^2	6.45162	929.0304	8361.274	1	10000.0
$Meters^2$	0.00065	0.0929	0.836	0.0001	1

Conversion Guides (cont'd.)

UNITS OF WORK

Unit	Foot-Pound (ft-lb)	Kg_fm	Joule	Kilo-Calorie (kcal)	British Thermal Unit (btu)	Kilowatt-Hour (kW-h)
Ft-Lb	1	7.233	0.7376	3087.0	778.6	26.55×10^5
Kg_fm	0.1383	1	0.102	426.9	107.6	36.71×10^4
Joule	1.356	9.807	1	4187.0	1055.0	35.97×10^5
Kcal	0.000324	0.00234	0.00024	1	0.252	860.0
Btu	0.00129	0.0093	0.00095	3.97	1	3413.0
kW-h	3.76×10^{-7}	2.72×10^{-6}	2.78×10^{-7}	0.00116	2.93×10^{-4}	1

Note: kg_f=kilograms force

UNITS OF POWER

Units	Horsepower (hp)	Kilowatt (kW)	Joule/Second (Watt)	Kcal/Second	Btu/Second
Hp	1	1.341	0.00134	5.614	1.415
kW	0.7457	1	0.001	4.187	1.055
Joule/s	745.7	1000.0	1	4187.0	1055.0
Kcal/s	0.1782	0.239	0.00024	1	0.252
Btu/s	0.7073	0.9484	0.00095	3.968	1

Note: to convert from units/sec. to units/min., divide by 60. 1 Joule/sec. = 1 watt

UNITS OF PRESSURE

Units	Lb_f/In^2 (PSI)	Lb_f/Ft^2 (PSF)	Pascal (Pa)	Bar	Kg/Cm^2
PSI	1	0.00694	0.000145	14.504	14.223
PSF	144.0	1	0.0209	2088.576	2048.112
Pa	6.89×10^3	47.88	1	1×10^5	9.81×10^4
Bars	0.06895	0.00048	0.00001	1	0.9807
Kg/Cm^2	0.07031	0.00049	0.0000102	1.0197	1

Note : 1 Pascal = 1 Newton/square meter (N/m^2) Lb_f = pounds force

Conversion Guides (cont'd.)

FRACTIONAL EQUIVALENTS

Fractional Inches	Decimal Inches	Milli-meter	Fractional Inches	Decimal Inches	Milli-meter
1/64	0.015625	0.397	**1/2**	0.50	12.7
1/32	0.03125	0.794	**17/32**	0.5312	13.494
3/64	0.046875	1.191	**9/16**	0.5625	14.288
1/16	0.0625	1.588	**19/32**	0.5937	15.081
3/32	0.09375	2.381	**5/8**	0.625	15.875
1/8	0.125	3.175	**21/32**	0.6562	16.669
5/32	0.15625	3.969	**11/16**	0.6875	17.463
3/16	0.1875	4.763	**23/32**	0.7187	18.256
7/32	0.21875	5.556	**3/4**	0.75	19.05
1/4	0.250	6.35	**25/32**	0.7812	19.844
9/32	0.2812	7.144	**13/16**	0.8125	20.638
5/16	0.3125	7.938	**27/32**	0.8437	21.431
11/32	0.3437	8.731	**7/8**	0.875	22.225
3/8	0.375	9.525	**29/32**	0.9062	23.019
13/32	0.4062	10.319	**15/16**	0.9375	23.813
7/16	0.4375	11.113	**31/32**	0.9687	24.606
15/32	0.4687	11.906	**1**	1.00	25.4

MESH COUNT CONVERSION FORMULAS*

Threads/Inch x .394 = Threads/cm
Threads/cm x 2.54 = Threads/Inch

THICKNESS CONVERSION FORMULAS

Microns x 0.03937 = Mils
Mils x 25.4 = Microns
Mils x 0.001 = Inches
Microns x 0.0001 = cm

THICKNESS CONVERSION CHART

Mils	Microns	Mils	Microns	Mils	Microns
1	25.4	9	228.6	17	431.8
2	50.8	10	254.0	18	457.2
3	76.2	11	279.4	19	482.6
4	101.6	12	304.8	20	508.0
5	127.0	13	330.2	21	533.4
6	152.4	14	355.6	22	558.8
7	177.8	15	381.0	23	584.2
8	203.2	16	406.4	24	609.6

*Data represents the closest possible approximation.

MESH COUNT CONVERSION CHART*

Threads /inch	Threads /cm	Threads /inch	Threads /cm	Threads /inch	Threads /cm	Threads /inch	Threads /cm
25	10	85	34	156	61	280	110
30	12	92	36	163	64	305	120
37	15	96	38	173	68	330	130
45	18	103	40	186	73	355	140
54	21	110	43	195	77	381	150
60	24	115	45	206	81	409	161
63	25	123	48	215	85	420	165
74	29	131	51	230	90	457	180
76	30	137	54	240	95	495	195
83	32	148	58	254	100	508	200

*Data represents the closest possible approximation.

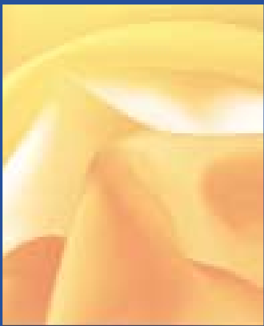
Conversion Guides (cont'd.)

SCREEN FABRIC SELECTION FORMULAS*

To Calculate For	Mesh Count (#/cm) & Thread Diameter (cm)	Mesh Count (#/cm) & Percent Open Area (%)	Image Thickness (cm) & Fineline Resolution (cm)
Mesh Opening Mo (cm)	$Mo = \frac{1\text{-}McD}{Mc}$	$Mo = \frac{\sqrt{A}}{Mc}$	$Mo = \frac{d_1\sqrt{\frac{Ih}{.364d_1}}}{5\left(1\text{-}\sqrt{\frac{Ih}{.364d_1}}\right)}$
Percent Open Area A (%)	$A = (1\text{-}McD)^2$	—	$A = \frac{1h}{.364d_1}$
Image Thickness Ih (cm) (Wet Film Ink Height)	$Ih = 1.82D\,(1\text{-}McD)^2$	$Ih = \frac{1.82A(1\text{-}\sqrt{A})}{Mc}$	—
Relative Strength S (cm²/cm)	$S = \frac{\pi McD^2}{4}$	$S = \frac{\pi Mc\,(1\text{-}\sqrt{A})^2}{4Mc^2}$	$S = \frac{\pi d_1^2}{100}$ or $\frac{5\left(1\text{-}\sqrt{\frac{Ih}{.364d_1}}\right)}{d_1}$
Fineline Resolution d_1 (cm)	$d_1 = 5D$	$d_1 = 5\,\frac{1\text{-}\sqrt{A}}{Mc}$	—
Halftone Dot Resolution d_2 (cm)	$d_2 = \frac{\sqrt{2}\,(1+McD)}{Mc}$	$d_2 = \frac{\sqrt{2}(2Mc\text{-}Mc\sqrt{A})}{Mc^2}$	—
Mesh Count Mc (#/cm)	—	—	$Mc = \frac{5\left(1\text{-}\sqrt{\frac{Ih}{.364d_1}}\right)}{d_1}$
Thread Diameter D (cm)	—	$D = \frac{1\text{-}\sqrt{A}}{Mc}$	$D = \frac{d_1}{5}$

Source: T. Frecska, *Screen Printing Magazine*
*Data represents the closest possible approximation.

Notes



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