Four-color Process and Fine Line Printing:

Do You *Really* Know What Your Mesh Count Is?

By Dawn M. Hohl

Screen printers have come to understand and rely on the mesh count of a screen as the main description of a screen printing fabric. Without this critical piece of information a mesh loses its identity. Decisions on mesh selection are based first on the mesh count no matter what the screen printing application. All this makes mesh count a vitally important dimension of screen printing fabric; one worthy of investigation and discussion.

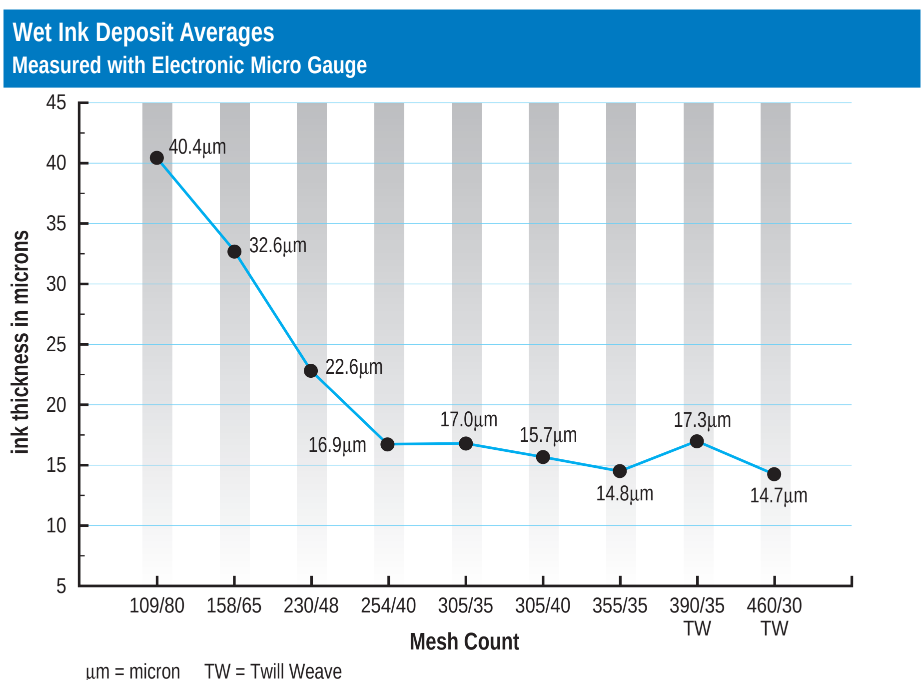
Some screen printing applications demand more accuracy and consistency from the mesh than others. In the case of four-color process and fine line printing, proper mesh selection is often essential to achieving desired results. Sufficient ratios of thread to dot/lines must be maintained in this type of printing for success to be possible.

SPTF
Screen Printing Technical Foundation
10015 Main Street
Fairfax, Virginia 22031
Telephone: 703-385-1335
Fax: 703-359-1336

So what would happen if a fabric's actual thread count per inch was nowhere near the mesh count labeled on the bolt? In fact, what if the actual mesh count could be compared to a lower mesh count also available from the same manufacturer - at a lower price? In close tolerance printing not only would this scenario cause lost value from incorrect material, but could cause significant loss of time and money on the production line from bad prints, wasted press time, wasted substrate, and wasted labor.

The question now becomes, can this hypothetical situation really occur. The answer is yes as the Screen Printing Technical Foundation's research will prove.

Figure 1



The SPTF, in the many studies conducted on polyester mesh, has discovered significant mesh count discrepancies not only from occasional manufacturer error, but resulting from stretching a fabric to tension. These differences could adversely affect close tolerance printing in terms of image resolution, color and overall quality. The intention of this paper is to identify the potential sources of mesh count differences and to provide the screen printer with practical methods for qualifying and dealing with discovered inconsistencies. Included is a discussion on the importance and practical use of mesh count, a list of measured mesh counts before and after tensioning on a variety of fabrics, and a recommendation for measuring, monitoring and controlling mesh count.

Mesh Count

The dimension of mesh count (Mc) is the most familiar characteristic of a screen printing fabric. Mesh count is simply the number of threads present in a unit length, with a unit generally being either one inch or one centimeter. The actual measurement and standard that is used by the fabric mills is threads per centimeter. Conversion to threads per inch can easily be accomplished by multiplying the threads per centimeter by (2.54).

The first and most obvious use of mesh count is in fabric selection and purchase. As stated earlier, the mesh count defines the density of a fabric's weave and allows printers to relate to the woven structure of a mesh. Without an understanding of this number, a relationship can not be determined between the mesh and the printing application. The mesh count enables the printer to begin matching the appropriate weave to a particular printing need, and serves as a specification when ordering mesh from a manufacturer or supplier.

A second usage for mesh count involves calculating ratios identifying thread support for halftone dot size, and for predetermining moiré potential for a given mesh count and halftone line count. Both practices are associated with four-color process and fineline resolution printing. These ratios and relationships assist in selecting appropriate mesh counts to carry varying degrees of image detail. Incorrect mesh selection in these instances can result in lost tonal ranges, moiré, excessive sawtoothing, and insufficient detail of halftone and fineline images. Many printers rely on these calculations to make educated decisions on mesh for these applications.

A detailed discussion of the various calculations used to determine mesh to dot relationships is out of the scope of this paper. A reference listing of articles describing various methods of calculating these ratios can be found at the end of this article. These articles also include further information on moiré and selecting mesh counts for given halftone and fineline images.

A belief commonly held by printers says that mesh count directly relates to the ink deposit thickness produced. The understanding has been that the higher the mesh count used, the less ink would be laid down. SPTF research has shown this to be untrue. Wet ink deposits measured on nine different mesh counts prove that ink thicknesses from mesh counts from 254 through 460 (Figure 1) do not steadily decrease, but remain similar across the board. These findings then indicate that the deposit resulting from the mesh (stencil thickness effect was not taken into account) is *not* connected with a fabric's mesh count.

As a result of this research, however, SPTF uncovered a direct link between fabric thickness and ink deposit thickness. A formula has been developed from this relationship that accurately predicts the wet ink deposit produced by a mesh. This formula offers significant improvements in predicting deposit over other formulas currently used in the industry. *(Further discussion of these findings are beyond the scope of this paper. Please contact the Screen Printing Technical Foundation for more information.)*

SPTF Research Results

SPTF has uncovered two main facts concerning mesh count differences. The first finding was that the mesh count of any fabric will decrease as tension increases. In some cases higher tension levels can decrease mesh count to match a lower count mesh. The second fact resulting from SPTF research revealed that there are sometimes discrepancies between the labeled mesh count and the measured mesh count of unstretched or free mesh. A more recent discovery was that occasionally meshes have been found to be mismarked directly on the salvage edge of the fabric, and actually measure a lower mesh count than labeled. It is important to state that mismarking does not occur often, and the majority of times the fabrics that are purchased are labeled correctly.

Mesh Count Changes During Tensioning

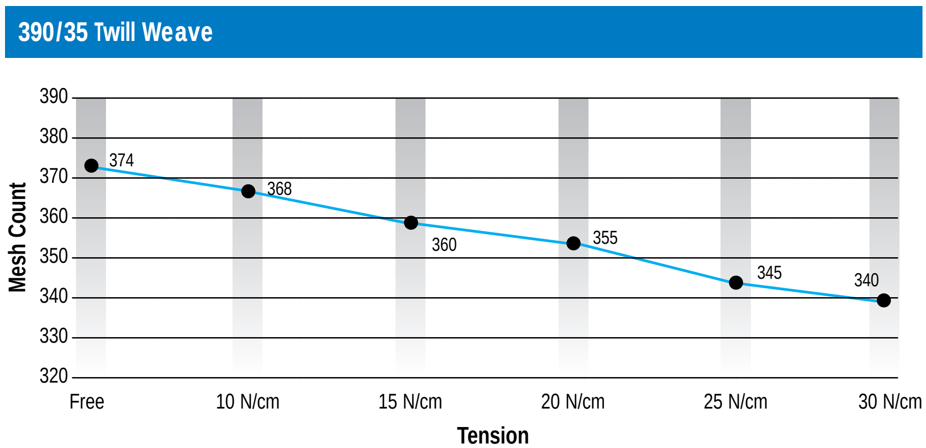
Research on the changes in polyester mesh during tensioning, including the changes in mesh count, has been documented and published in a SPTF research report entitled *Changes in Polyester Mesh During Tensioning*. Let us briefly review the conclusions reached from this research.

The main phenomena identified during the testing was a steady decrease in the mesh count as tension was increased on polyester mesh. An illustration of this effect on a 390 mesh can be found in Figure 2.

In this example mesh count decreased a total of 34 threads per inch from its free state to 30 N/cm of tension. At 20 N/cm the mesh, which is labeled a 390 has become a 355. While this particular mesh changes a great deal, others do not change as drastically under the same tension conditions, in Table 1.

The measurements taken on these meshes typify the reaction of all the fabrics SPTF has tested to date. Some meshes exhibit a greater change than others under the same tension levels. Generally, lower mesh counts (lower than 200) tend to change less with tension than the higher mesh counts (200 and up). Many fabrics have been tested in this manner and have reacted similarly. The degree of

Figure 2



Note: All mesh counts are an average of a warp and weft measurement and are in threads per inch. Measurements were done with a mesh counter at each tension level.

TW = Twill Weave

Table 1

All numbers in threads per inch

Mesh	Mesh Count Free*	Mesh Count At Tension*	Tension in N/cm+	Percent Change
305/34 LE	301	294	20	2.2%
305/35 LE	309	293	22	5.5%
390/35	375	356	20	5.5%
390/31 LE	385	378	19	2.0%
390/27 LE	373	353	20	5.4%
420/27 LE	409	390	19	4.6%
460/27 LE	457	432	20	5.5%
460/30	455	432	19	5.1%

* Average of warp and weft mesh count + Average of warp and weft tension

change the mesh count undergoes seems to vary from mesh to mesh. Different manufacturers, mesh material types (regular vs. low elongation), weave types and other variables may cause the mesh to change at different rates during the tensioning process. Therefore, there is no way to predict the degree of change the mesh count will experience for any given tension without previously testing a mesh.

Two other significant facts were revealed about the mesh count. The first deals with the differences between the warp and the weft mesh count measurements, and the second with the repeatability of change a mesh possesses from screen to screen.

Comparisons between the measurements of the warp mesh count and weft mesh count showed differences of as much as 20 to 25 threads per inch. Some fabrics had very little difference between directions, and others had notable contrasts. No consistent trends can be identified to indicate if a mesh will possess a large difference in mesh count between directions, or if the mesh count in the warp or weft direction will be larger or smaller.

The question of repeatability was addressed by testing 5 mesh samples from the same bolt of fabric under identical conditions. Mesh count was measured during tensioning and recorded for all five samples. The results of one of the screens tested is listed in Table 2. Very little difference is seen from sample to sample under the same tension conditions. The five samples vary only 1-2 percent from the average, indicating that screens made from the same bolt of fabric will have the same final mesh count when stretched using identical procedures.

Table 2

305/34 Mesh	Mesh Count Free	Mesh Count 20 N/cm	Mesh Count 30 N/cm
Sample 1	300	293	288
Sample 2	302	297	284
Sample 3	301	292	287
Sample 4	300	293	291
Sample 5	301	293	288

Table 3

All numbers in threads per inch

Mesh	Mesh Count Free*	Difference between measured and manuf. mesh count	Mesh Count 25 N/cm *	Difference between measured and manuf. mesh count
A 355/33 PW	331.4	23.6	323.8	31.2
B 355/34 PW	326.4	28.6	318.8	36.2
A 355/33 TW	295.9	59.1	285.7	69.3
B 355/34 TW	335.0	20.0	323.8	31.2
A 390/33 PW	373.3	16.7	363.2	26.8
B 390/34 PW	365.7	24.3	351.7	38.3
A 390/33 TW	363.2	26.8	360.6	29.4
B 390/34 TW	369.5	20.5	351.7	38.3

* Average of warp and weft mesh count

PW = Plain Weave

TW = Twill Weave

Measured Mesh Count versus Manufacturer's Specifications

Most manufacturer information on mesh is relevant only when the fabric is in the free state. This includes the specifications on mesh count as well as fabric thickness, mesh opening size and percent open area. Changes in all of these parameters occur during the tensioning process. Even in a free state however, the actual mesh count can differ from the labeled count a great deal. Some examples of these differences are seen in Table 1 and Table 3. The third table represents results from a plain weave and twill weave mesh comparison study. Notice the significant differences in the free mesh count measurements in almost all of the 355 and 390 mesh counts listed. One 355 mesh stands out having an actual mesh count of approximately 296. Quite obviously this mesh has been mismarked, and was probably intended to be a 305 fabric. The mismarking on this fabric took place directly on the salvage edge of the mesh. It is important to note that a mistake like this is rare and should not destroy the confidence screen printers have in the mesh manufacturers. Fabric weaving mills have tightly controlled processes and generally produce a reliable and consistent product.

Two things may be concluded from the data presented here. First, on rare occasions, fabrics supplied from the manufacturers may be mismarked. Again, this is not a common event as most fabrics are correctly labeled. Second the mesh count specified by the manufacturer or distributors may differ from the actual free mesh count of a mesh. Both of these facts will add support to recommendations for measurement and control of mesh count.

Manufacturer Specifications

A brief discussion is in order regarding the manufacturers' specifications and tolerances for the mesh they produce and sell. As stated before, the information they supply to the industry is based on the free or untensioned state of a mesh. To compare their numbers to tensioned measurements, therefore, is not a fair practice. Some manufacturers will indicate a tolerance or a range that the mesh count of their fabric will fall. This range should be taken into account when comparisons are made.

It should be obvious to the reader that discrepancies of 1 to 10 threads per inch is negligible and is no cause for concern. The weaving process, like any other process, has natural variations that will produce slight differences in mesh count across the bolt and from roll to roll. This must be considered when evaluating mesh.

Some differences between specified and measured mesh counts can be traced to marketing decisions made years ago. One instance of this involves 390 mesh counts. Many manufacturers and distributors are actually providing a 380 mesh for a 390. The misrepresentation of this fabric can be traced back to earlier days in the industry when one manufacturer began providing a 390 mesh count and another, previously supplying a 380, was compelled to change the specification to a 390 in order to compete. The change remains today in many manufacturers' products.

Practical Example Scenarios

Two example scenarios will be explored to give the reader some relevant reasons for measuring mesh count.

Mesh Ratios

If 355 fabric is considered to determine the highest halftone ruling that can be printed without moiré, the following situation would occur. Referencing Mark Coudray's article "Understanding Halftone Moiré," a 355 mesh will indicate a capability of printing 75 lines per inch with little possibility for moiré. A 305 however is only rated for 65 lines per inch for the same condition. In addition the ratio for a 355 is higher than that for a 305 indicating a better ability to print small dot sizes. If a 305 is inadvertently used where a 355 is needed, chances are detail will be lost, and moiré is more likely to emerge in the print. The same would be true if a 390 mesh when tensioned becomes a 355.

Cost Savings

In the case where a mesh is found to be mismarked in its free state, money may be recovered based on the difference between the specified and actual mesh count. As an example let us take the mismarked 355 mesh from Table 3. An approximate cost of a 355 fabric is $32.50 per yard for a 45" width. The mesh is actually a 305 mesh costing $22.65 per yard for the same width. For a 20 yard roll the difference in cost is $197 dollars. If the difference is discovered at a quality control checkpoint, the mesh can be returned or a refund provided to compensate for the error. Keep in mind that differences resulting from stretching are not the manufacturers' responsibility, but something inherent in *every* mesh.

Recommendations for Control

Measurement

The task of measuring mesh count is a simple one that can be done with a variety of instruments. A device suited to measuring this characteristic must address two points to achieve accurate data. First, it must magnify the threads to the point that they are countable. Secondly, some type of calibrated reticule or gauge must be present in the viewing area to accurately determine the distance over which to measure.

A mesh counter was designed for this measurement and is pictured in Figure 3. It consists of a 50 power microscope with a crosshair stationed over defined areas of view. This particular instrument assists the operator by defining the distance to measure and offering a crosshair reference reticule that easily moves over the defined area at the operator's command. Several measurement widths are provided on the instrument including 10 mm, 1/4 inch and 1/2 inch.

Another instrument that can be used to count mesh is a Digital Linear Gauge. This device is more expensive and sophisticated, and can be used to measure distances on many other things in addition to mesh count. These are just two examples of manufactured instruments that can be used for this application. Other methods and devices can be adapted and used to accurately measure mesh count.

SPTF used a mesh counter to complete the research on mesh count differences included in this application bulletin. The procedure developed for measuring mesh count in SPTF's testing is outlined in Table 4.

Notice that a 10 millimeter or 1 centimeter distance was chosen, and is being recommended for mesh count measurement. The reasons for this choice are twofold. First, in counting the threads present in a full centimeter variations present in the mesh count can be fully measured and represented. When 1/2 inch and 1/4 inch distances are used to count threads, the resulting numbers must by multiplied by 2 and 4 respectively to represent the full inch measurement. This practice could cause slightly inaccurate numbers due to actual mesh count variations occurring over an entire inch. The second reason for using 10 mm is that this number can be directly compared to the manufacturer's information in centimeters, which as explained earlier, is the actual measurement taken at the mills. Mesh count in threads/cm can easily be converted to threads/inch by multiplying by (2.54).

Checkpoints for Control

The mesh supplied to the industry can be considered an incoming material to the screen printing process. In stretching the material, changes takes place to screen mesh in direct relation to the tension level achieved. However, while the printer causes change through tensioning, the mesh count a fabric possesses in its free state and the *degree* of change produced by tensioning are independent characteristics that are fixed at the time of its manufacturing. These two independent factors can only be monitored by the printer as a step to ensure consistent screens are produced.

Based on these two variables, SPTF is recommending two checkpoints where mesh count should be monitored. The first mesh count check needs to take place when a new bolt of fabric is received from the manufacturer/distributor. This could be considered an incoming

Figure 3

quality control checkpoint on mesh. It is recommended that all *important* mesh counts are checked at this point to catch the occasional mismarked mesh from slipping through, and to provide a point to compare the new mesh to the mesh count measured on previous bolts of fabric (of the same mesh count) from the same manufacturer. The screen printer will have to determine what mesh counts are important based on the printing applications that are involved.

Records should be kept of this information in some appropriate form. Statistical Process Control charts offer an excellent means of documenting and analyzing this information. Another good practice would be to attach an additional tag to the bolt or create a list indicating the manufacturer specifications and the measured mesh count for easy reference.

The second point where mesh count should be measured on a screen is after it is stretched to the final printing tension. This is especially important when tensions reach 20N/cm and more. The *degree of change* in mesh count, explained earlier, will vary from mesh to mesh and manufacturer to manufacturer, but should remain repeatable for all the mesh on a bolt of fabric. Because of the mesh's repeatability, mesh count at a particular tension will only have to be measured once. If several tensions are used for different applications, each one should be measured once. Mesh stretched on retensionable frames will need to be remeasured if the working tension is increased during the life of the screen.

Again, records should be kept to document the actual mesh count at all the tensions used for a mesh. SPC charts are again an option, but a list or chart can also be used. While record keeping can be burdensome and time consuming, taking the trouble to measure mesh count without writing down the resulting data is a complete waste of time. Documentation must follow quality control measurements for the acquired information to help in controlling the process.

Table 4

Procedure for Determining Mesh Count Per Centimeter with a Mesh Counter

1. Position the fabric, free or tensioned, on a light table.
2. Locate the 10 mm measuring area on the microscope.
3. Move the microscope to the left edge of the 10 mm area using the thumb screw control.
4. Focus the image and position the reticule cross hair on the left edge of the 10 mm area.
5. Position the mesh counter on the fabric so the left side of a thread is touching the left edge of the 10 mm area, and the threads are parallel and perpendicular to the crosshair.
6. Using the crosshair as a reference, move the microscope to the right with the thumbscrew and count the number of threads in the 10mm area. If there is 50% or more of a thread inside the measuring area at the right edge, count it as a whole thread. If there is less than 50% of the thread showing, don't count it at all.
7. Measure and record the mesh count in both the warp and weft directions. The direction the microscope moves is the direction of the fabric you are measuring.
8. Calculate the average mesh count by adding the warp and weft count and dividing by 2.

Conversions: threads/inch x .394 = threads/cm   threads/cm x 2.54 = threads/inch

Practical Benefits

How can knowing the actual mesh count help in solving practical problems? The most obvious use of the mesh count that we have already discussed is in calculating ratios for four-color process and fine line printing. An example of how using the manufacturer's specifications on a mismarked mesh or a mesh that has changed considerably during tension can mislead a printer's judgment in selecting mesh has been shown. Having the correct information available to use for the calculations will therefore eliminate inaccurate ratios and better aid the printer in the selection process.

Recording the printing results of a certain halftone line count, halftone screen angle, and tonal range on a mesh with the actual mesh count specified will also serve as a reference for future mesh selection decisions. Should a particular combination work, the printer will have confidence to use it again. Once more, the same mesh count can be ensured in the screen making department by the measurements taken at the incoming quality control checkpoint and at its working tension. However if a combination fails, the mistake can be avoided again, and another mesh can be used for the job.

Long-term documentation of this kind can be very valuable in four-color process and fine line screen printing. Standard conditions and procedures can be developed leading to more consistent and predicable products. By not repeating past mistakes, a great deal of time and money can be saved, making room for more jobs to be completed. Further benefits will be derived from these concepts if they are applied to other areas where control is needed.

Recommended Course of Action

Once a significant mesh count discrepancy is found in the measurements taken at the checkpoints outlined above, action may be required to correct the situation. In the rare case of a mismarked mesh that is discovered at the incoming quality control check, the manufacturer or distributor where the mesh was obtained should be notified. The printer may then request an exchange of the mismarked mesh for the originally ordered mesh count. If the printer can use the mesh count that was inadvertently sent, a refund or credit for the difference in price between the two should be requested if appropriate.

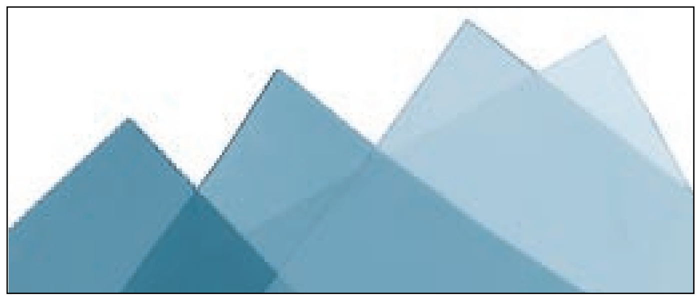
As shown in the SPTF research results section of this article, all mesh will change to some degree under tension. If the measured mesh count taken at the working tension of a mesh is significantly low, and unacceptable for the application it was intended for, the printer has several options. Again, it is wise to notify the manufacturer or distributor with the situation, and attempt to resolve the problem with them. Another option is to endeavor to find a mesh undergoing less change when brought up to the same tension level by testing fabrics. The third and simplest option however is to use a higher mesh count for the job.

If the measured mesh count of a particular fabric has changed significantly from the original count, but experience with that mesh has proven its ability to accomplish the desired print results from a particular image, no course of action may be needed. In this case, the incoming quality control checkpoint and working tension checkpoint measurements should simply be used to ensure that the count will be the same as in previous runs.

Conclusion

As stated in the beginning of this paper, some screen printing applications will demand more accuracy and consistency from the mesh than others. The recommendations contained in this paper will not apply to everyone. Printers must determine if mesh count is important to the printing application they are involved in, and make a decision on whether or not more control is needed for better results. The guidelines presented here are for those who rely on the mesh count dimension to help them achieve certain print results.

It is important to note that the recommendations here will by no means solve all process and fineline printing problems. Screen printing is a multi-facteted process with many variables to control. What is presented here is simply *one step* of many that the printer should take to better control the consistency of screens used in these types of applications. With the screen being the *single most important element of the process*, time taken to improve its quality and repeatability can only result in more consistent and predicable results on the final print.



Mesh and Moiré Ratio References:

Baragona, John. "Serilor® Log Moiré Guard." *Screen Printing Network,* (April, 1993) 18-19.

Baxter, Geoff; Clark, Joe. "Moiré in Textile Screening: Identification, Isolation and Prevention." *Impressions,* vol. 12 (May, 1988) 146-162.

Clark, Joe. "The Mesh: Process Printing on T-shirts Control Point No.5." *Screen Printing,* vol. 76 (March, 1986) 54-58.

Coudray, Mark. "Understanding Halftone Moiré." *Screen Printing,* vol. 81 (October, 1991) 142-147 .

Coudray, Mark. "You Can Minimize Halftone Moiré." *Impressions,* vol. 17 (August, 1993) 173-178.

Duccilli, Steve; Goodridge, Mark; Latscha, Craig. "Comparative Screen-Fabric Guide." *Screen Printing,* vol. 83 (April, 1993) 64A-64P.

Frecska, Tamas. "Problems & Ideas: Halftone Screen Printing." *Screen Printing,* vol. 74 (December, 1984) 141-142.

Frecska, Tamas. "Problems & Ideas." *Screen Printing,* vol. 74 (October, 1984) 285-286.

Nersesian, Bob. "four-color Halftone Printing Part 2." *Screen Printing,* vol. 73 (June, 1983) 90-93.

Tambini, Margaret. "Selecting Fabrics for Halftones: Basic Guidelines." *Screen Printing,* vol. 76 (February, 1986) 56-59.

Scheer, Hans-Gerd. "four-color Halftones in Screen Printing." *SPAI Technical Guidebooks,* vol. I, Article C7 (1982).

Scheer, Hans-Gerd. "Screen Printing Criteria in Halftone Printing." *SPAI Technical Guidebooks,* vol. I, Article C15 (1987).

Note: References to specific brands does not imply any endorsement of products by the Screen Printing Technical Foundation.