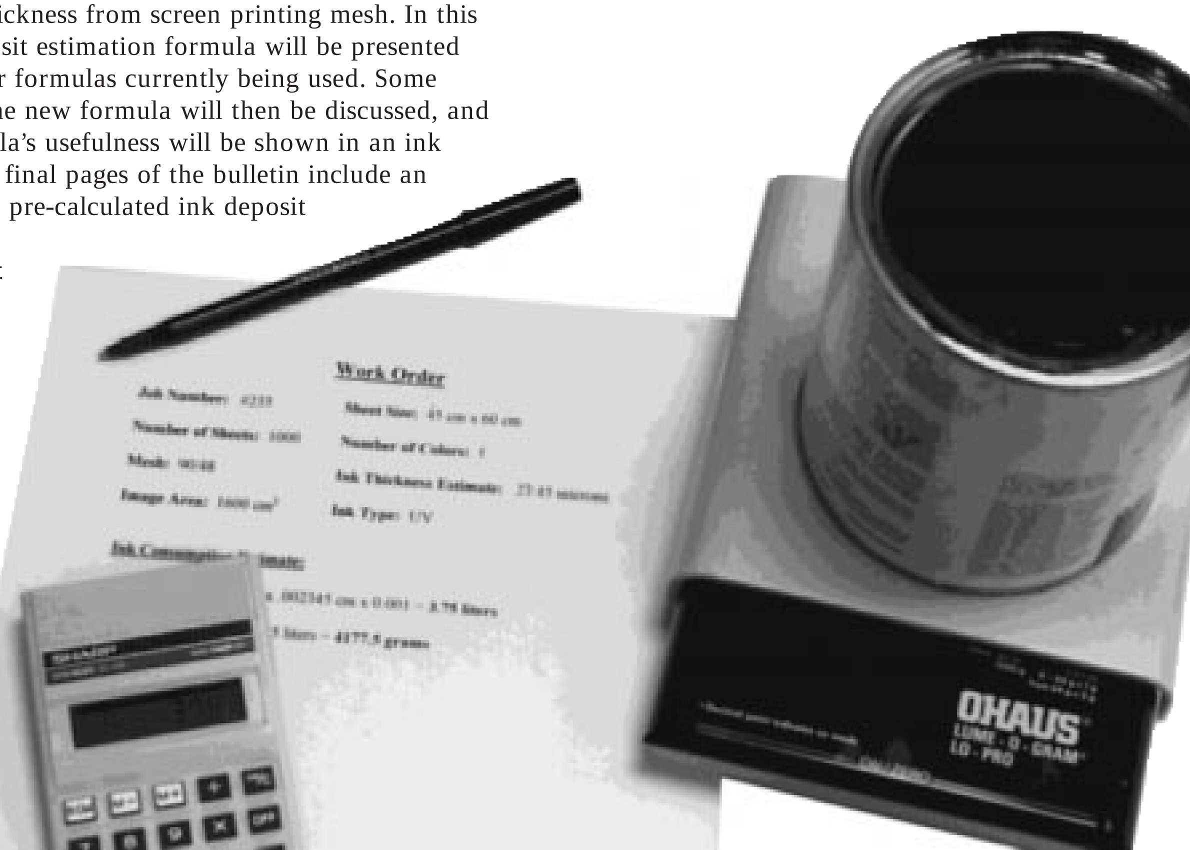
Estimating Ink Deposit in Screen Printing: Improving Your Accuracy

Do Your Ink Estimates Relate to Reality?

By Dawn M. Hohl

Ink deposit. While it is discussed to a certain extent in the screen printing industry, it has not been seriously addressed and understood by screen printers. Yet ink deposit is one of the key results from the process affecting things like color, density, opacity, ink cure or drying time, and performance characteristics of a print. Most printers are busy trying to get the color, density, opacity, ink cure, etc., right, while ignoring a vital parameter that would help make **consistent success** in these areas possible. It is time we gave the ink deposit thickness, and the variables that affect it, their just due.

The Screen Printing Technical Foundation started looking at various aspects of ink deposit thickness at the very outset of the research efforts. One of the most important accomplishments made in this area has been the development of a new formula for predicting ink deposit thickness from screen printing mesh. In this bulletin, SPTF's ink deposit estimation formula will be presented and compared with other formulas currently being used. Some practical tips for using the new formula will then be discussed, and an example of the formula's usefulness will be shown in an ink estimation problem. The final pages of the bulletin include an easy reference chart with pre-calculated ink deposit estimates using SPTF's formula. **Please note that metric units are used exclusively throughout this paper. A conversion guide is provided at the end for those interested in English units.**



SPTF

Applications For Accurate Ink Height Estimates

There are many educated decisions that a screen printer must make before successfully printing a job. Many of these decisions are related to ink thickness. Let us look at some of the areas where ink deposit estimates are of use.

1. **Ink Consumption –** Printers that mix customized colors for jobs understand the importance of accurately estimating the correct amount of ink needed to run a job. If too much is mixed, the company loses money as the extra ink sits on the shelf and eventually needs to be disposed of as waste. The exception to this is when the customer repeats an order, or when the color can be used in another job. If too little is made the color must be mixed again, and if the exact formula was not recorded, more than likely the color of the second batch will differ from the first, causing problems. Estimating the correct ink quantity for a job will help eliminate storage space, lower waste, and lower ink costs in the company. One of the critical elements to estimating ink consumption for a printing job is using an accurate ink thickness in the formula. Job costing is another area where accuracy will pay off. Good ink consumption estimation may make a bid for a job lower than the competition by minimizing ink charges.

2. **Mesh Selection –** Decisions on what mesh to use for a job are often based in part on the theoretical ink volume or some other type of ink deposit estimate. Better ink deposit estimates on fabrics will lead to better mesh decisions.

Table 1

Four Formulas Currently Being Used for Estimating Ink Deposit Thickness

1. The higher the mesh count the lower the deposit
2. Theoretical Ink Volume $V(th) = \frac{Mo^2 \times Ft}{(Mo + D)^2}$
3. $Ih = Ft \times (\%A \div 100)$
4. Frecska $Ih = (1.82 \times D) \times (1 - McD)^2$

Ih =	Estimated Ink Height	D =	Thread Diameter
Ft =	Fabric Thickness	Mc =	Mesh Count
%A =	Percent Open Area (*calculation:* $(1 - McD)^2 \times 100$)	Mo =	Mesh Opening

3. **Color Matching –** The ink deposit thickness is extremely influential in color matching applications. It becomes important not only on the press, but in testing the formulation against the target color by eye or with a color computer. Testing requires that a sample be made, and in many companies this is accomplished with screen printing. Being able to predict the ink thickness from a mesh becomes very useful in this process. This topic is covered in detail in SPTF's Practical Application Bulletin entitled *"Color Matching: Controlling Ink Deposit For Accurate Matches."*

4. **Opacity –** The opacity of an ink is not only dependent on the ink's pigment load, but on the thickness applied. When a job has opacity requirements it is helpful to estimate ink thickness on various fabrics so the proper mesh can be selected to produce the desired results.

5. **Four-Color Process Printing –** Attention to ink thickness in process printing is a necessity if a printer is to achieve and maintain the proper ink density and color balance. Knowing the ink deposit a mesh will generate will help in the selection process.

6. **Ink Curing –** Minimizing ink deposit is necessary when printing with UV ink so that cure can be attained easily. Mesh for UV printing is often selected on this basis. Improvements in the ink deposit estimate for mesh will again lead to better decisions.

7. **Performance Characteristics –** There are applications where a specific thickness must be printed to create certain performance characteristics. One example would be in electronics printing. Being able to predict the ink deposit from a mesh is valuable in these situations.

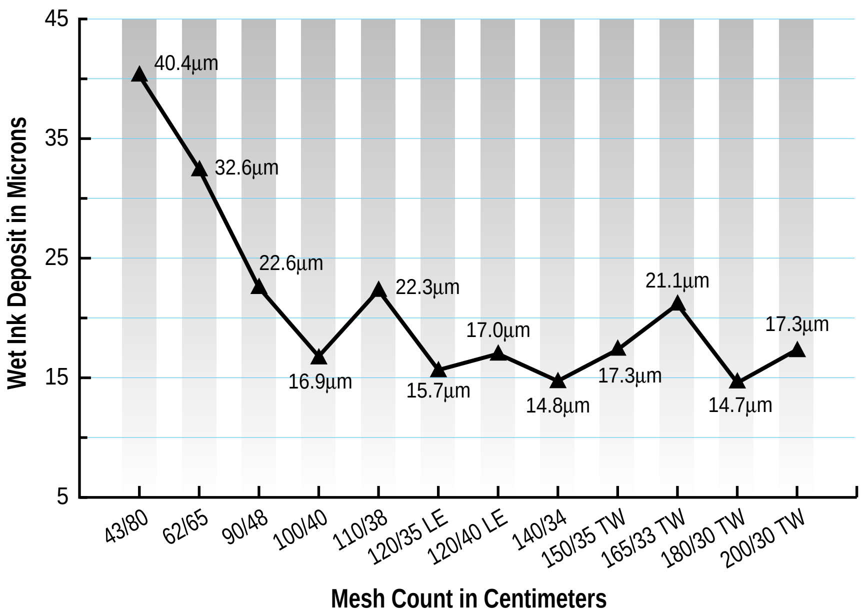
The information contained in this bulletin can help those seeking to improve their ability to make decisions in the areas listed above.

Current Industry Formulas for Estimating Ink Thickness

Over the years there have been numerous methods and formulas presented in the screen printing industry to predict the ink thickness from a given mesh. Some of these methods are very technical and complex (such as Riemer's and Huner's theories presented in the *ISHM Journal*) while others are

Figure 1

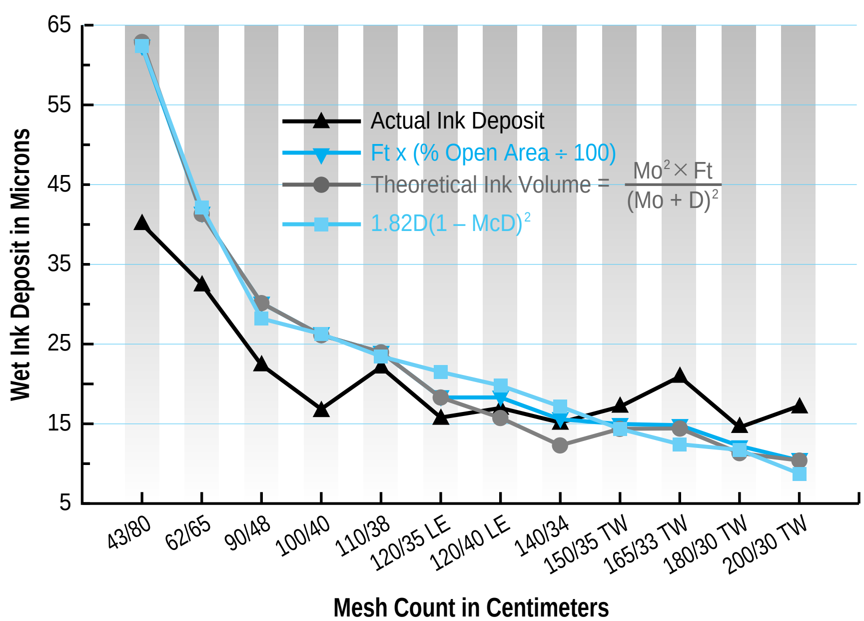
Actual Ink Deposit vs. Mesh Count



Wet ink deposits made with a multi-purpose UV ink were measured on twelve different mesh counts ranging from 43 to 200 (Mc/cm), showing that actual wet ink deposit is not directly related to mesh count as previously thought.

Figure 2

Actual Ink Deposit vs. Various Estimates



Three currently used methods to estimate ink deposit are plotted against actual wet ink deposits from twelve meshes.

fairly simple. Many of the mesh manufacturers include a column in their specifications listing a theoretical ink volume calculation. There are too many formulas to cover in this bulletin, so SPTF has chosen four of the most common for discussion (**Table 1**).

First on the list is probably the simplest general theory currently held in industry which says mesh count relates to ink deposit thickness. The assumption has been that with each progressively higher mesh count, less ink will be deposited. SPTF research has shown this to be untrue. Wet ink deposits made with a multi-purpose UV ink were measured on twelve different mesh counts ranging from 43 to 200 threads/cm **(Figure 1)**. The graph shows a declining ink deposit trend from the 43 to 100 (threads/cm) mesh count range, but the curve's average flattens from the 100 through to the 200 (threads/cm) mesh. These findings indicate that the deposit thickness resulting from the mesh alone (stencil thickness effect was not taken into account) is **not** directly connected with a fabric's mesh count. Therefore, the method of linking mesh count to ink deposit can not be used effectively.

The second and third formulas produce very similar ink estimates. Theoretical ink volume is commonly seen in mesh manufacturer's specifications, and is what many printers deal with.

The fourth and final formula was developed by Tamas Frecska, and has appeared in articles (see references) and in the first "Comparative Screen-Fabric Chart" published by *Screen Printing* magazine in 1988. The formula here is different from the third only in that the fabric thickness is estimated with the 1.82xD rather than using the manufacturer information. The ink estimate it calculates is slightly different from formulas two and three.

The formulas themselves are self explanatory. The resources they were taken from are listed in the

Table 2

Actual Wet Ink Deposit Compared to Calculated Estimates

Mesh (Mc in cm/D)	Actual IH (microns)	V(th) (microns)	Ft (mfg.) × (%A ÷ 100) (microns)	1.82D $(1-McD)^2$ (microns)	Mo (mfg.) (microns)	%A = $(1-McD)^2 \times 100$ (Percent)	Ft (mfg.) (microns)
43/80	40.4	63.3	62.2	62.6	160	43.0	143
62/65	32.2	40.9	40.9	42.1	96	35.6	115
90/48	22.6	29.8	29.9	28.2	63	32.3	93
100/40	16.9	25.9	25.9	26.2	60	36.0	72
110/38	22.3	23.7	23.7	23.4	53	33.9	70
120/35 LE	15.7	18.1	18.1	21.4	48	33.6	54
120/40 LE	17.0	15.7	17.8	19.7	38	27.0	66
140/34	14.8	12.3	16.0	17.0	29	27.5	58
150/35*	17.3	14.3	14.7	14.4	31	22.6	65
165/33*	21.1	14.2	14.5	12.4	27	20.7	70
180/30*	14.7	11.1	11.9	11.6	24	21.2	56
200/30*	17.3	10.4	10.4	8.7	20	16.0	65

* Twill Weave mesh
LE = Low Elongation Mesh (not specific to manufacturer)
IH = Actual Ink Height
V(th) = Theoretical Ink Volume
%A = Percent Open Area
D = Thread Diameter
Mc = Mesh Count in cm
Mo = Mesh Opening
Ft = Fabric Thickness
mfg. = Manufacturer Specification

references for the reader who wishes to get more detail on their origination and rational. Please note that to use these formulas correctly, all of the numbers must be in the same units. SPTF's *Measurement and Conversion Guide* can give the factors to make these changes.

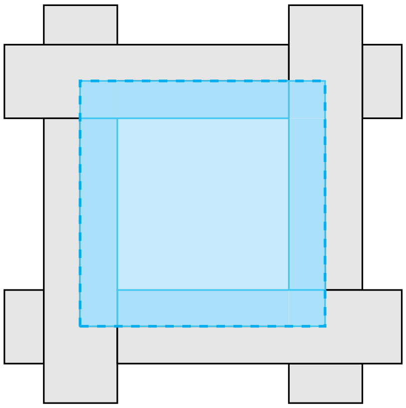
In **Figure 2** these three calculated estimates are plotted against the actual wet ink deposits produced from the 12 different fabrics shown in Figure 1. Notice first that all three formulas are very alike in their estimates **(Table 2)**. A downward trend of ink deposit thickness as mesh count increases is also evident in these calculations. It is likely that the first methodology discussed is based on the results of these estimation formulas. In comparing these estimates to the actual deposits the differences are obvious, especially in the lower and higher mesh counts. Some of the estimates are fairly close to the actual deposits in the middle mesh counts shown here. However, overall correlation between the estimate curves and the actual deposit curve is not as good. Clearly the ink estimates produced by these formulas do not track well with reality.

The SPTF Formula

One of the Foundation's earliest projects involved measuring the dimensions of screen printing mesh and the changes that occurred to those dimensions during the tensioning process. (A published report entitled "*Physical Changes in Polyester Mesh During Tensioning*" includes the details of this study.) The information generated in this work made it possible to develop a mathematical model defining the total volume of ink that a mesh cell would hold **(Figure 3)**. The resulting model not only accounts for the normally used cube of ink based on the mesh opening size, but also includes all of the area existing above and below the threads. As seen from the cross section in **Figure 4**, there is substantial space around these threads that holds ink in addition to the opening itself.

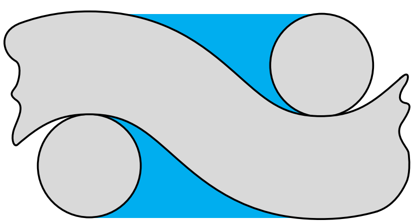
While the initially developed formula is too complex to present in this bulletin, the logic behind its development was to define the total volume of a mesh cell and mathematically extract the volume the threads occupied in that space. The remaining space represents the true volume occupied by ink in a mesh cell (**Figure 5)**. SPTF research, exploring the changes that occur on mesh during tensioning, confirmed that there are often significant differences between the dimensions measured before and after tensioning.

Figure 3



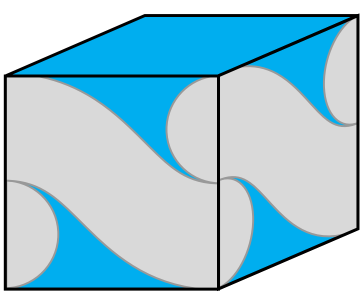
Length and width dimensions of a mesh cell.

Figure 4



Volume of ink contained above and below the threads of a mesh cell.

Figure 5



Three dimensional cross section of a mesh cell with the highlighted areas showing the true volume of ink being contained.

For this reason the formula incorporates the measured values of the four mesh parameters taken at printing tension.

The formula was exceptionally successful at predicting the actual wet ink deposit of the twelve mesh counts already discussed. Further investigation into the relationships between ink thickness and mesh revealed a ratio between the measured fabric thickness and wet ink deposit.

The ratio can be calculated by dividing the actual ink deposit with the measured fabric thickness. After calculating this ratio for all the meshes tested in the ink deposit study, they were averaged together to come up with a single factor. It was found that this factor could be multiplied by the fabric thickness to produce a wet ink estimate for a mesh. The initial study produced a factor of 0.28499 (often rounded to 0.285), which has been published in several places.

Another project involving comparisons between plain and twill weave meshes took the research to the next step. Ink deposits were printed and measured on the eight meshes covered in the study, but when the ratio was calculated there were two distinct factors that emerged, both different from the first factor of 0.285. One ratio defined the transfer characteristics of twill weave mesh, while a different ratio described plain weave mesh. This resulted in two additional factors, each one appropriate for a specific group of fabrics. The factors, when to use them, and their limitations are outlined in **Table 3.**

As mentioned in the table, the formula calls for the factor to be multiplied by the measured fabric thickness at tension. The reasons for this and the correct measurement

Table 3

SPTF Ink Height Estimation Formulas

For Plain Weave Mesh Counts of 43 to 130 (threads/cm)

Estimated Ih (microns) = 0.285 × Ft (microns)*

For Plain Weave Meshes with a Mesh Count of 140 (threads/cm) and higher

Estimated Ih (microns) = 0.35 × Ft (microns)*

For Twill Weave Meshes

Estimated Ih (microns) = 0.31 × Ft (microns)*

**** The fabric thickness should be measured at tension. Using the manufacturer's specified fabric thickness generally will not produce as reliable an estimate. Please read the section on measuring fabric thickness in the practical tips section of this bulletin before attempting to use these formulas.***

Formula Limitations

- Only verified at SPTF on polyester mesh printed with multi-purpose UV ink (however results from the field seem to indicate this formula is superior in accuracy compared to old methods)
- Do not apply to polyester meshes with a 27 micron thread
- Do not apply to calendered mesh
- Do not apply to stainless steel mesh

techniques are covered in the fabric thickness section of this bulletin. The reader is strongly urged to read that information on this extremely important area before proceeding with these calculations.

With the factors having been defined, let's look at a graphic depiction of SPTF's estimates against the actual ink deposit and an old estimate in **Figure 6 and Table 4**. It is immediately obvious that SPTF's estimate closely tracks with the actual ink thickness produced on these twelve meshes under a standard set of conditions. The old estimate falls short in comparison to this new method.

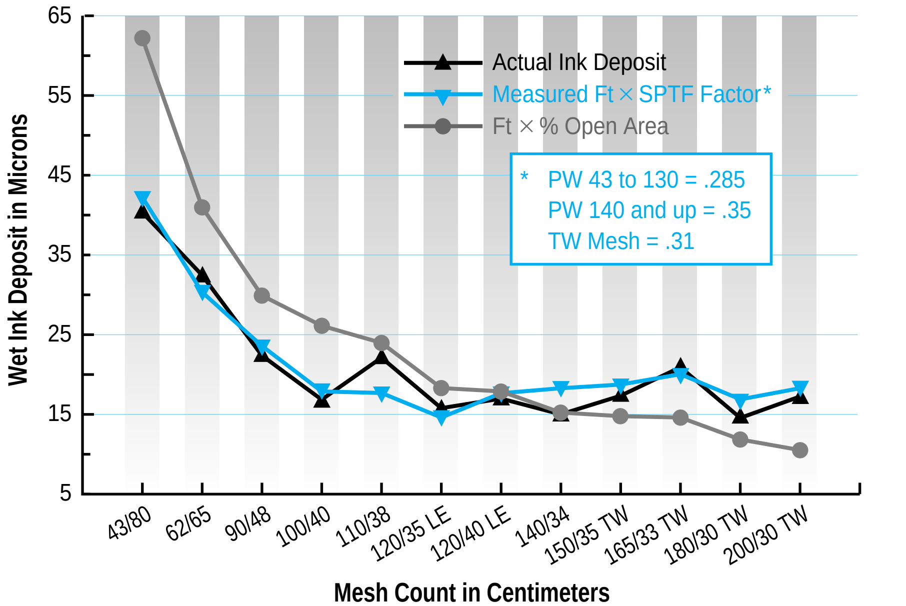
In **Figure 7 and Table 5** we see a second comparison involving the meshes tested in the plain weave-twill weave study. Here results with the two additional factors are compared to the actual deposit and an estimate using the original 0.285 factor. The differences are significant and provide justification for the existence of the two new factors.

It is expected that further revisions and refinements will be made on these factors as more research is completed. Other areas of invesigation for SPTF include the effect of different inks and substrates on ink deposit, as well as the effect of stencil thickness on the ink deposit in small image areas.

The SPTF formulas that have been presented here are intended as a tool to provide a more accurate comparative estimate of ink deposit thickness. Current industry methods only give a general estimate of deposit, and SPTF's model is no different in its purpose. Also important to note is that SPTF's estimate formula does not account for the effect from stencil thickness. The stencil thickness will add to the ink deposit in small image areas. The additional thickness can have a drastic effect on the color and density, and should be counted on if printing fine detail.

Figure 6

Actual Ink Deposit vs. Estimates



SPTF's new method of estimation compared to both the actual wet ink deposit and an old estimate on twelve mesh counts.

Table 4

Ink Deposit Study: Estimate Comparison Chart

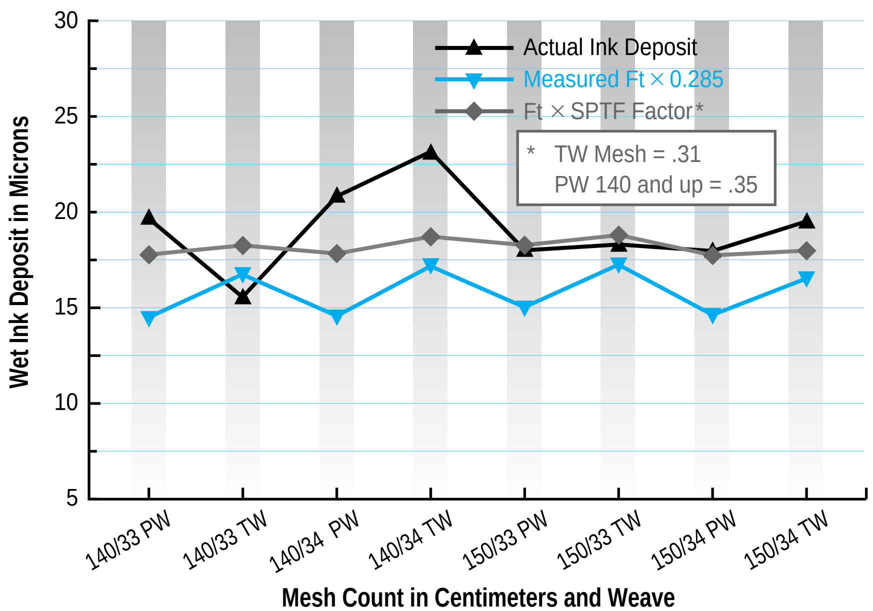
Mesh (Mc in cm/D)	Actual IH (microns)	Ih = Ft¹ × SPTF factor* (microns)	Ih = Ft (mfg.) × (%A ÷ 100) (microns)	Measured Ft at Tension (microns)
43/80	40.4	41.9	62.2	147.0
62/65	32.2	30.8	40.9	108.0
90/48	22.6	23.5	29.9	82.3
100/40	16.9	17.9	25.9	62.7
110/38	22.3	17.5	23.7	61.5
120/35 LE	15.7	14.4	18.1	50.4
120/40 LE	17.0	17.3	17.8	60.8
140/34	14.8	18.2	16.0	52.0
150/35 TW	17.3	18.7	14.7	60.4
165/33 TW	21.1	20.0	14.5	64.6
180/30 TW	14.7	16.7	11.9	54.0
200/30 TW	17.3	18.3	10.4	59.0

Ft¹ = Measured fabric thickness at tension
* PW mesh 43 to 130 (Mc in cm) = 0.285
PW mesh 140 (Mc in cm) and up = 0.35
TW mesh = 0.31

PW = Plain Weave
TW = Twill Weave

Figure 7

Plain Weave – Twill Weave Study
Actual Ink Deposit vs. Estimates



Results from the plain weave – twill weave study show the improvements from the two additional factors that were discovered by comparing their estimates to the estimates using the single factor first

Table 5

Plain Weave – Twill Weave Study
Estimate Comparison Chart

Mesh (Mc in cm/D)	**Actual IH** (microns)	**Ih = Ft¹ × SPTF factor*** (microns)	**Ih = Ft¹ × 0.285** (microns)
A 140/33 PW	19.76	17.82	14.51
A 140/33 TW	15.52	18.29	16.81
B 140/34 PW	20.84	17.82	14.51
B 140/34 TW	23.22	18.76	17.24
A 150/33 PW	17.98	18.31	14.91
A 150/33 TW	18.32	18.85	17.32
B 150/34 PW	18.02	17.75	14.45
B 150/34 TW	19.54	17.98	16.53

Ft¹ = Measured fabric thickness at tension
* PW mesh 140 (Mc in cm) and up = 0.35
TW mesh = 0.31

PW = Plain Weave
TW = Twill Weave

Variables that will Affect Ink Thickness

There are a number of highly influential variables that can change the resulting ink deposit thickness in the screen printing process. The printer must realize that changing these variables can produce a wet ink deposit that may differ from the estimated value. As stated earlier, the estimate formulas presented are not able to predict the changes caused by these variables, and are therefore not to be considered absolutes. They simply serve to compare one mesh to another.

Some of the primary factors that affect ink deposit include the mesh, ink, substrate and stencil (in the case of small image areas). Secondary factors to be taken into account are the squeegee variables of pressure, angle, speed, durometer, and free height, not to mention the off-contact distance. There are other factors as well that will have an effect in some situations. The primary variables are more likely to create greater changes in ink thickness than the secondary parameters. The printer should keep these things in mind when using ink estimates.

Practical Tips

Measuring Fabric Thickness

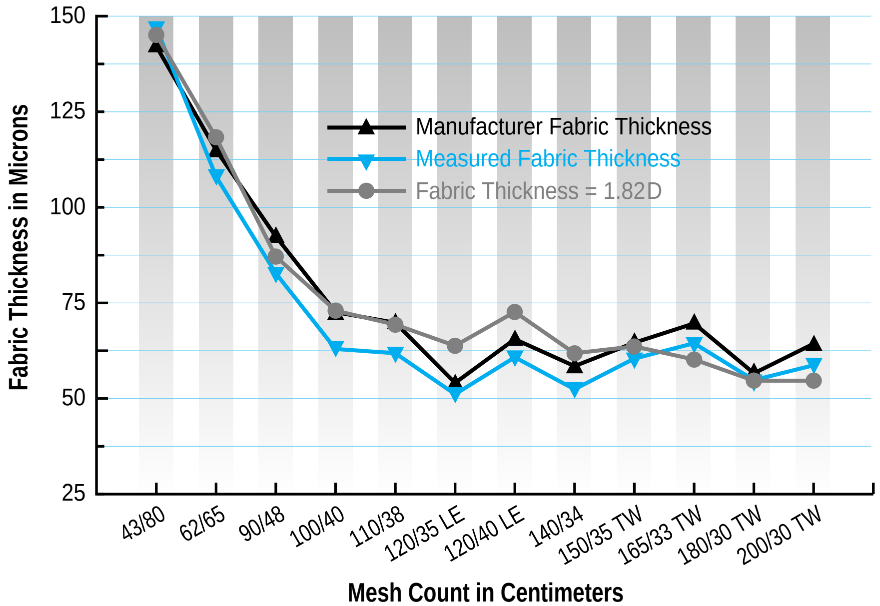
Much of SPTF's estimate accuracy depends on the preciseness of the fabric thickness. The Foundation has documented the fact that fabric thickness changes as tension is applied to a mesh, and that the measured fabric thickness taken at tension is typically different from the specification supplied by the manufacturer **(Figure 8)**. The formula that is used in industry to calculate fabric thickness, Ft = 1.82xD, does not give results consistent with the measured fabric thickness either **(Table 6)**. The only way to obtain the correct fabric thickness is to measure it on the tensioned screen.

Methods to measure the fabric thickness of mesh on a frame are somewhat limited. Most mechanical thickness measurement devices, such as micrometers, have a limited reach and are not able to get around a frame to measure fabric. However, electronic thickness gauges do not have this restriction and are able to access the center of a screen and read thickness on the micron level with accuracy and ease.

Two methods of electronic measurement are appropriate for screen printing applications, magnetic induction and eddy current. Both types measure non-magnetic and non-ferrous coatings, which to the screen printer would include screen mesh, stencil, most substrates, and dry ink deposit. In order for these devices to measure a thickness they must have a particular kind of material in back of the item that is being tested. In the case of a magnetic induction unit a ferromagnetic base must be used, and for an eddy current device an aluminum or aluminum alloy base is needed. The most common of these two methods being used in

Figure 8

Fabric Thickness
Manufacturer vs. Measured



Measured fabric thickness taken at tension is typically different from both the specification supplied by the manufacturer and the calculation of 1.82xD for determining fabric thickness.

Table 6

Fabric Thickness Comparison Chart

Mesh (Mc in cm/D)	Manufacturer Ft (microns)	Ft = 1.82D (microns)	Measured Ft at Tension (microns)
43/80	143	145.6	147.0
62/65	115	118.3	108.0
90/48	93	87.4	82.3
100/40	72	72.8	62.7
110/38	70	69.2	61.5
120/35 LE	54	63.7	50.4
120/40 LE	66	72.8	60.8
140/34	58	61.9	52.0
150/35*	65	63.7	60.4
165/33*	70	60.1	64.6
180/30*	56	54.6	54.0
200/30*	65	54.6	59.0

* Twill Weave Mesh

Figure 9

A new screen printing probe gives more repeatable and accurate measurements on mesh and stencils without any special calibration.

the screen printing industry is magnetic induction. Many know this type of instrument as a "Deltascope," which is actually a model name used by one manufacturer for their gauge of this type.

Researchers at SPTF have conducted many capability studies with electronic thickness gauges over the years. Specifically we have evaluated their accuracy and repeatability in measuring fabric thickness, stencil thickness, substrates and dry ink deposits. In the capability study on fabric thickness, a significant error was discovered in the readings obtained from the magnetic induction method compared to measurements taken on proven mechanical systems, including an Electronic Micro Gauge (EMG) and two different micrometers.

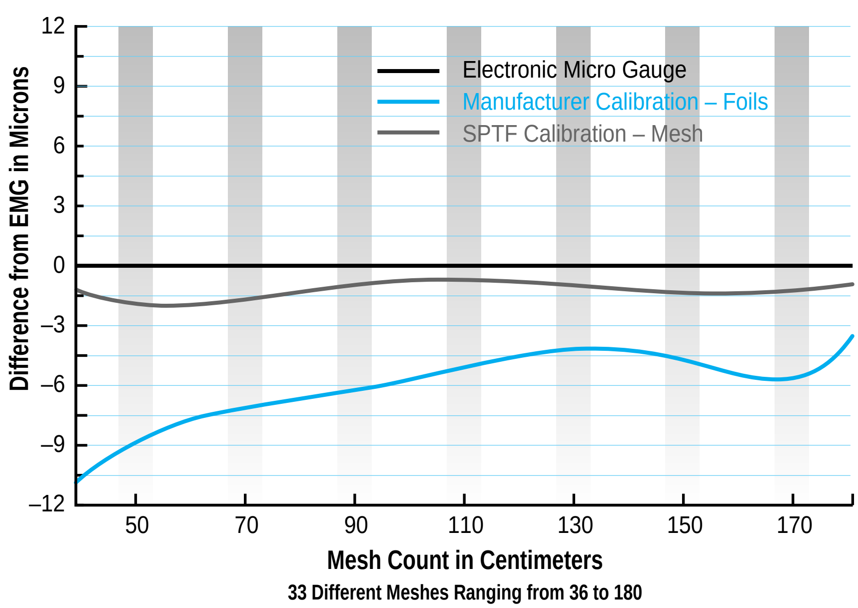
The magnetic induction unit that was tested was an older model with the standard probe used for general applications.

Recently, one manufacturer introduced a new probe specifically designed for screen printers **(Figure 9)**. SPTF testing on this new probe found it to work very well on measuring fabric without any special calibration. The new probe also gives more repeatable measurements on stencils. Those who are planning to purchase this type of device should consider getting this probe rather than the one regularly sold. However, many screen printing companies have older units that do not have this specially designed probe. As we will discuss, fabric thickness measurements with these old style probes will be inaccurate using the standard calibration foils supplied with the instrument. This error can be corrected by using a special calibration technique, making the instrument perfectly useful for measuring fabric thickness.

In an initial capability study, the magnetic induction device (using a standard probe) was calibrated according to manufacturer's instructions using the supplied polyester foils. Thirty-three different meshes were measured ranging from a 36 to 180 (threads/cm) mesh count, varying in thickness between 170 to 53 microns. The Electronic Micro Gauge was made the standard, and these reference measurements were subtracted from the readings taken with the magnetic induction device. The difference was then graphed, and can be found in **Figure 10**. The zero line represents the reference measurements, or the true fabric thickness, and the lower curve shows

Figure 10

Magnetic Induction Instrument on Mesh
Error Reduction Achieved with SPTF Calibration



Error reduction achieved on fabric thickness measurements with a magnetic induction instrument using SPTF's calibration technique the error in the readings that result when a magnetic induction system is calibrated with the supplied foils. Notice that the error does not remain constant but increases as the lower mesh counts are measured. Without a constant offset, using a fixed value to adjust the reading is not effective. For this reason, other corrective measures were explored.

From this research SPTF has developed a new calibration technique that significantly reduces the error seen here. The top curve in **Figure 10** illustrates the improved results of the new calibration technique. There is only a slight difference present and it is much more consistent throughout the mesh count range tested. The error reduction is significant and greatly improves the accuracy of the instrument in fabric thickness measurements.

Simply explained, the revised calibration is done using screen mesh standards instead of the polyester foils that the manufacturer provides. A detailed step-by-step procedure describing how to implement this new calibration method can be found in **Table 7**.

Calibration procedures will vary depending on the manufacturer and model. Newer models may not allow the foils to be replaced with mesh unless the fabric is approximately the same thickness as the foil. Generally the thickness values of the foils are out of range with thicknesses of mesh, so you will not be able to calibrate with the mesh in this case. If the unit offers a corrective calibration option the mesh can be introduced at this point. Many older models, on the other hand, will allow mesh to be substituted for the foils. What the unit will allow or not allow you to do depends on the manufacturer, the model, and the age of the unit.

Preliminary research on eddy current systems has shown similar errors in fabric thickness measurements with the standard calibration. Using SPTF's calibration brings readings from this unit in line

Table 7

Calibrating Magnetic Induction and Eddy Current Instruments to Measure Fabric Thickness

1. Determine if your instrument has a special screen printing probe, or if you have a standard probe. If you have a standard probe proceed with steps 2-6. If you are using the screen printing probe, no special calibration is required to measure fabric thickness accurately. Measurements may be made after the unit has been calibrated according to the manufacturer's directions.

2. Select one to three mesh counts (depending on how many calibration points the gauge requires) that represents a cross section of available mesh counts. SPTF suggests the following: For 3 point calibration use 36/100, 90/48, and 150/34 (*English equivalent 92/100, 230/48, 390/34*). For 2 point calibration use 43/80 and 150/34 (*English equivalent 110/80 and 390/34*). For 1 point calibration use 90/48 (*English equivalent 230/48*). You may also contact the author at SPTF to obtain pre-measured mesh standards of the mesh counts just mentioned.

3. Acquire a small sample (6 cm x 8 cm) of each mesh count and take 10 measurements of fabric thickness in different spots on each sample with a thickness micrometer resolving to 2.54 microns or lower. Light pressure must be used when measuring mesh with a micrometer so it is not crushed. Use the slip ring if it does not apply too much pressure so your readings will be more consistent. It is also important to turn the anvil slowly when measuring. Turning it fast will apply more pressure.

4. Calculate the average fabric thickness of the 10 readings for each mesh. These mesh samples will now be used as standards to calibrate the magnetic induction or eddy current instrument.

5. Calibrate the instrument according to manufacturer's instructions, using the mesh standards in place of the foils. Some of the newer units have a master calibration where you must use the foils, and then have a corrective calibration option where mesh may be introduced to eliminate the error.

6. When the calibration with mesh is complete, you are ready to measure fabric thickness **only**. The instrument must be recalibrated with the supplied foils if the stencil, substrate or ink deposit is to be measured.

Procedure for Measuring Fabric Thickness

1. Calibrate the magnetic induction or eddy current device according to the above procedure. If the instrument has been previously calibrated with mesh, check the calibration by measuring the mesh standards. If the readings do not closely match the known fabric thickness of the samples, recalibrate.

2. Measure and record 5 to 10 readings in various places toward the center of the fabric on the screen.

3. Obtain the average of the 5 to 10 numbers from the statistical options of the device, or calculate it by adding all the numbers together and dividing by the number of measurements that were taken. Use the mean as the fabric thickness of the mesh.

Conversions

microns × 0.03937 = mils	mils × 0.001 = inches
mils × 25.4 = microns	micron × 0.0001 = centimeters

with reality. Therefore the new calibration method is also practical for the eddy current gauge when measuring fabric thickness.

It becomes apparent that without properly calibrating these devices the fabric thickness readings they give will not be useful in calculating a wet ink deposit estimate with SPTF's formula. If this new estimation method is to be effective, attention must be given to getting accurate fabric thickness values.

Both magnetic induction and eddy current devices perform well on stencils, substrates and dry ink deposits when the normal calibration is done with the polyester foils. No special procedures need to be used in these applications. **Note:** Stencil thickness measurements should be performed with the regular calibration even though the fabric must be measured by itself. In this instance it is not important that the fabric thickness reading is not accurate as only a relative difference is required between this measurement and the stencil/mesh combination to get stencil thickness.

Measuring Wet and Dry Ink Thickness

There are many instruments and devices on the market that are designed for wet and dry ink thickness measurement. These instruments have a wide range of sophistication and price. A discussion on many of these systems has already been covered in SPTF's three part research report entitled *"A Guideline to Wet and Dry Ink Deposit Measurement Methods."*

There are two physical states where an ink deposit can be measured. When an ink is just printed and wet, or when it has been dried or cured. The estimates in this paper give numbers that can be related to wet ink thickness. In the case of most inks (including UV), the dry thickness will be significantly different from the wet thickness of the deposit.
The printer must understand these distinctions in order to use the estimates appropriately.

The question of whether to measure wet or dry ink deposit has many aspects to consider. Wet deposits are much more difficult to measure than dry. Not only are wet samples unstable, but reliable measuring instruments are often costly for this application. There are some low cost wet deposit measurement devices out there, but results obtained from them are often very inaccurate. Dry deposits on the other hand are very easy to measure with low cost instrumentation that gives accurate results.

A more important comparison comes when we look at what wet and dry thickness information can be used for. Wet measurements are the best indicator of changes in the screen printing process, and will give the actual deposition thickness that is occurring. Uses for wet values include monitoring the consistency of the process, determining the effects of press variables on deposit, and determining the volume of ink being laid down. Dry measurements do not consistently track variations in the process, but they are an excellent indicator of the finished product, even if the ink system varies during the length of the run. The best use for dry measurements is in characterizing the finished product.

While the best situation would include both wet and dry deposit measurements, this is not always feasible. Decisions on which one to pursue must be based on how the thickness information is to be used. Careful consideration should be given before reaching such a decision.

Measuring UV Inks

At this point a special comment on measuring the ink deposit on UV curable inks is necessary. SPTF research has confirmed that UV inks shrink in thickness anywhere from 25-50% when they are cured. *(This research is included in the SPTF research report entitled "Polyester Mesh Capability Study with UV Inks.")* Therefore the dry thickness measured cannot be directly related to the wet thickness unless previous testing confirms that that particular ink consistently shrinks a certain amount at a certain ink thickness. **Incorrect conclusions will occur if a 2% reduction of wet to dry thickness is assumed.**

It is understood that changes in the factors affecting cure, including belt speed, lamp wattage, heat and substrate, will affect the degree a coating is cured. If the UV ink is not fully cured the dry thickness will vary and will not be reliable. In addition, the time the measurement is taken may be important and should be standardized as UV inks undergo a post cure. To date, the effects of post curing in UV inks have not been researched by the SPTF. It is unknown whether additional shrinkage occurs during this time.

Ink Consumption Problem: Using Old and New Ink Deposit Estimation Methods

To take wet ink deposit estimation to a practical level, let's consider a simple ink usage scenario. For comparison purposes, we will calculate the amount of ink for a particular job using the old estimate, new estimate and actual ink deposit.

The job requires a print run of 1000 sheets with a one color line design having an area of 1600 square centimeters. For simplicity's sake, estimates for ink used in setup, the screen, overrun sheets, and rejects will not be dealt with in these examples.

The general formula used here for estimating the quantity of ink needed for this job is:
(number of sheets) × *(image area in square centimeters)* × *(wet ink thickness in centimeters)* × *0.001(to convert to liters) = ink usage in liters*

Example #1 - 90/48 Mesh (Mc in cm/D)

Actual Ink Deposit = 22.56 microns = .002256 centimeters

SPTF Ink Deposit Estimate = 23.45 microns = .002345 centimeters

Old Ink Deposit Estimate = Ft × (%A÷100) = 29.9 microns = .00299 centimeters

Actual Ink Deposit

1000 sheets × 1600 cm^2 × .002256 cm × 0.001 = 3.61 liters

SPTF Ink Deposit Estimate

1000 sheets × 1600 cm^2 × .002345 cm × 0.001 = 3.75 liters

Old Ink Deposit Estimate = Ft × (%A÷100)

1000 sheets × 1600 cm^2 × .00299 cm × 0.001 = 4.78 liters

In this first example, using the old ink estimate over-calculates the amount of ink needed to actually run the job. The new SPTF estimate is very close to what the job would require. The difference between the two methods is over a liter of ink.

Example #2 - 165/33 TW Mesh (Mc in cm/D)

Actual Ink Deposit = 21.10 microns = .00211 centimeters

SPTF Ink Deposit Estimate = 20.03 microns = .002003 centimeters

Old Ink Deposit Estimate = Ft × (%A÷100) = 14.50 microns = .00145 centimeters

Actual Ink Deposit

1000 sheets × 1600 cm^2 × .00211 cm × 0.001 = 3.38 liters

SPTF Ink Deposit Estimate

1000 sheets × 1600 cm^2 × .002003 cm × 0.001 = 3.20 liters

Old Ink Deposit Estimate = Ft × (%A÷100)

1000 sheets × 1600 cm^2 × .00145 cm × 0.001 = 2.32 liters

The second example shows an under-estimation of ink when the old ink deposit estimate is used. While the SPTF estimate is slightly under the actual ink usage, it is much closer than the old method. Proper estimation methods would add in a small percentage of extra ink for safety, making up for this slight underestimation in SPTF's method. However, this extra ink would not be enough to make up the difference using the old estimate, which is a little over a liter less.

Conclusions

As stated earlier, it is expected that further revisions and refinements will be made on these formulas as SPTF completes more research. Ultimately, each step taken to define the effect of the process's variables will lead to better methods of prediction and control. These improvements will be published as they are discovered.

For those who are interested in a deeper study on this subject, a technical report expounding on the original mathematical model of the mesh cell and dealing with the transfer rates of mesh will be published by SPTF in the future.

SPTF Estimate Table

The last page of this report contains of a table designed to assist and speed ink estimation using SPTF's new method. It includes pre-calculated estimates for a list of fabric thicknesses with each of the three factors. To use it, simply measure the fabric thickness of the mesh you wish to estimate, select a table using the appropriate factor for that mesh, look up the fabric thickness in the table and read the wet ink deposit estimate to the right of the matched fabric thickness.

Conversions:
microns × 0.03937 = mils
micron × 0.0001 = centimeters
mils × 0.001 = inches
mils × 25.4 = microns
liters × 0.264 = gallons
$centimeter^2$ × 0.15502 = $inch^2$
centimeter × 0.3937 = inch
threads/inch × 0.394 = threads/cm
threads/cm × 2.54 = threads/inch

Suggested Reading List:

A Guideline to Wet and Dry Ink Deposit Measurement Methods Part I,II, and III, SPTF Research Report by Dennis D. Hunt and Dawn M. Hohl, 1990.

Physical Changes in Polyester Mesh During Tensioning, SPTF Research Report by Dawn M. Hohl and Dennis D. Hunt, 1992.

Polyester Mesh Capability Study with UV Inks, SPTF Research Report by Dawn M. Hohl and Dennis D. Hunt, 1991.

Four-Color Process and Fine Line Printing: Do you Really Know What Your Mesh Count Is?, SPTF Practical Application Bulletin by Dawn M. Hohl, 1994.

Color Matching: Controlling Ink Deposit for Accurate Matches, SPTF Practical Application Bulletin by Dawn M. Hohl, 1995.

For information on how to obtain a copy of the above reports, please contact the Screen Printing Technical Foundation at (703) 385-1417, 10015 Main Street, Fairfax, VA 22031.

References

Duccilli, Steve; Goodridge, Mark; Latscha, Craig. “Comparative Screen-Fabric Guide: Mesh Selection Without the “Eeny, Meeny, Miney, Mo.” *Screen Printing*, vol. 83 (April 1993) 64A-64 O.

Elliott, James; Frecska, Tamas. “Fe Fi Fo Fum, What’s the Best Mesh for a Halftone Run? and Comparative Screen-Fabric Chart.” *Screen Printing*, vol. 78 (April 1988) 63-64.

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Frecska, Tamas. “Screen Fabrics? A Question of the Right Parameters.” *Screen Printing*, vol. 75 (February 1985) 54-102.

Scheer, Hans-Gerd. “Influence of the Stencil Fabric on the Thickness of Ink Deposit & Consumption of Inks.” *SGIA Technical Guidebook*, vol. I, (1979), Article D7.

SPTF Estimate Table

After measuring the fabric thickness of a mesh, identify which of the three factors the mesh falls under. Look up the fabric thickness in that column and read the pre-calculated wet ink deposit estimate to the right.

Note: All values in microns

Plain Weave Mesh
43-130 Mc in cm (110-330 Mc in inches)
SPTF Ih = Ft x .285

Ft	SPTF Ih	Ft	SPTF Ih
130	37.1	89	25.4
129	36.8	88	25.1
128	36.5	87	24.8
127	36.2	86	24.5
126	35.9	85	24.2
125	35.6	84	23.9
124	35.3	83	23.7
123	35.1	82	23.4
122	34.8	81	23.1
121	34.5	80	22.8
120	34.2	79	22.5
119	33.9	78	22.2
118	33.6	77	21.9
117	33.3	76	21.7
116	33.1	75	21.4
115	32.8	74	21.1
114	32.5	73	20.8
113	32.2	72	20.5
112	31.9	71	20.2
111	31.6	70	20.0
110	31.4	69	19.7
109	31.1	68	19.4
108	30.8	67	19.1
107	30.5	66	18.8
106	30.2	65	18.5
105	29.9	64	18.2
104	29.6	63	18.0
103	29.4	62	17.7
102	29.1	61	17.4
101	28.8	60	17.1
100	28.5	59	16.8
99	28.2	58	16.5
98	27.9	57	16.2
97	27.6	56	16.0
96	27.3	55	15.7
95	27.1	54	15.4
94	26.8	53	15.1
93	26.5	52	14.8
92	26.2	51	14.5
91	25.9	50	14.3
90	25.7		

Twill Weave Mesh
(all mesh counts)
SPTF Ih = Ft x 0.31

Ft	SPTF Ih
75	23.3
74	22.9
73	22.6
72	22.3
71	22.0
70	21.7
69	21.4
68	21.1
67	20.8
66	20.5
65	20.2
64	19.8
63	19.5
62	19.2
61	18.9
60	18.6
59	18.3
58	18.0
57	17.7
56	17.4
55	17.1
54	16.7
53	16.4
52	16.1
51	15.8
50	15.5

Plain Weave Mesh
140 Mc in cm and above
(355 Mc in inches)
SPTF Ih = Ft x 0.35

Ft	SPTF Ih
65	22.8
64	22.4
63	22.1
62	21.7
61	21.4
60	21.0
59	20.7
58	20.3
57	20.0
56	19.6
55	19.3
54	18.9
53	18.6
52	18.2
51	17.9
50	17.5
49	17.2
48	16.8
47	16.5
46	16.1
45	15.8