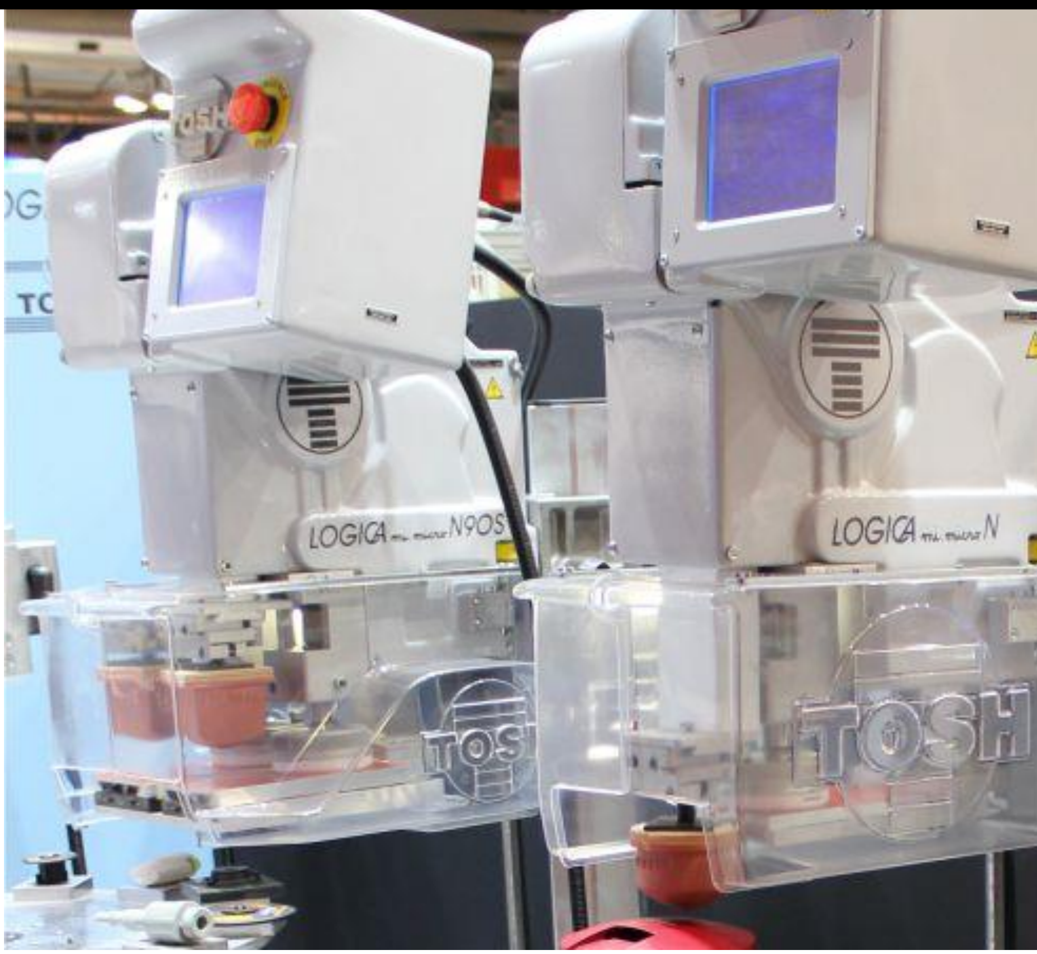
Modern Pad Printing - 2016



John Kaverman with **Trent Pepicelli**

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Modern Pad Printing / John P. Kaverman / September, 2016

Modern Pad Printing

Introduction

"Pad printing is a science, *not* an art."

If you read this entire book and take away only those eight words, you will be a more effective pad printing technician than most.

I've been printing stuff for almost thirty years, and pad printing exclusively for twenty. This is the fourth "book" I've written about pad printing, and the second in the past two years.

Pad printing technology is constantly evolving, at least when it comes to one manufacturer: TOSH. In the United States, TOSH is distributed exclusively by Innovative Marking Systems. That is the one reason why Trent Pepicelli's name and photo appear on this edition of Modern Pad Printing.

More importantly, Trent's name appears because I've worked with Trent both directly (as his national sales manager from 2000 – 2010) and indirectly (as an engineer and consultant for another ten years) for twenty years. Most of what I've learned about pad printing has been a result of the experiences that we've had working together in one capacity or another.

We both hope that you will find this book a useful resource.

John Kaverman

1. The Origins of Pad Printing

There are several theories, the most popular of which suggests that the process was originally "discovered" by Swiss watch makers. Printing watch faces was extremely difficult using any existing process, and hand painting was impractical. Borrowing from several processes, the Swiss supposedly created a new process, which eventually came to be known in Europe as *tampondruck.*

The German word "tampon" is a noun which loosely translated meant "absorb" or "transfer". Johannas Gutenberg, the inventor of mechanically movable type, used a "tampon" to absorb ink and manually transfer it to the type for printing over 500 years ago. "Druck" means "print" in German. The word "tampondruck" therefore means "transfer print". The process is only infrequently referred to as "tampography", however. Most people simply say "pad printing".

Today pad printing often competes with screen printing, hot stamping, ink jet marking, in-mold labeling and several other processes used to decorate objects. While the final result may appear similar, pad printing is fundamentally different than any of these processes. The clever use of solvent evaporation that allows pad printing to transfer an image out of an etched plate and onto the part makes it a bit more complex than most other processes.

The use of the pad printing process was mainly limited to Europe until the early 1970's when a few manufacturers introduced their products to North America. A retired designer from Mattel (the toy company) told me several years ago that he thought they were the first to use it in the United States, for printing on Hot Wheels.

As the popularity of the process grew, pad printing competed directly with the more traditional hot stamping and screen printing for industrial decorating business. As people began to see the benefits of pad printing versus the other two processes a niche market developed.

Companies using hot stamping quickly realized that pad printing could decorate the majority of their products faster and with less wasted material. Screen printers found that pad printing worked better for decorating three-dimensional objects, including those having compound angles. The niche quickly turned into a new industry. By the end of the 1980's the number of pad printing equipment manufacturers and distributors more than doubled in the United States. Today pad printing competes not only with screen printing, hot stamping and ink jet printing, but also with the in-mold decorating, heat transfer and direct digital imaging processes.

The list of potential applications for pad printing is seemingly endless. The average person probably comes into contact with dozens if not hundreds of pad printed products on a daily basis without knowing it.

It really is amazing when you stop to think about all of the products that are decorated with pad printing, yet when I tell someone that I am a consultant specializing in pad printing they get that look on their face that tells me they have no idea what I am talking about. Most of the time I just resort to some object that has been pad printed as a prop to accompany a brief explanation of the process.

2. How Pad Printing Works

The theory behind the pad printing is kind of an amalgamation of the screen, rubber stamp and rotogravure printing processes, combined in a way that is entirely unique.

In the beginning, copper plates were etched with recessed images similar to the gravure printing process. Since then, materials and methods have changed, but the end result is still a plate etched with a recessed image. In pad printing, we refer to the printing plate as a "*cliché*". The word cliché comes from the German "Klischee", which means "plate". I've heard it also referred to as a "*stereotype".* In modern English, both words have been overused to the point of having lost their original meaning all together.

The surface of the plates are then flooded with ink and wiped (or "doctored") clean similar to the way a screen is flooded with ink and then squeegeed clean in the screen printing process. In pad printing, however, this doctoring action does not result in the immediate transfer of the image to the substrate as it does in screen printing.

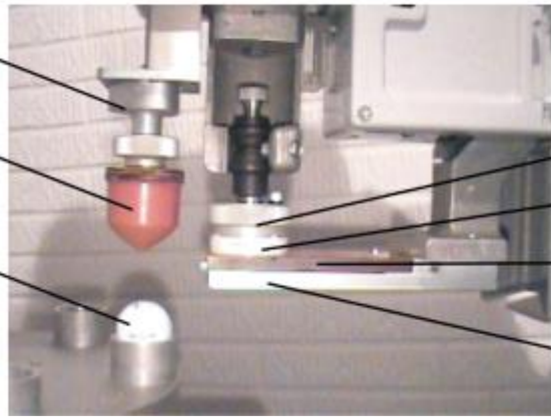
Once the top surface of the plate is cleaned the pad is then compressed first onto the plate to pick up the image, then onto the substrate to transfer the image. This is similar to rubber-stamp printing, but notably different in that the pad is a means of transfer rather than the source of the image.

In the next chapter you will see that there are numerous types of pad printing machines. All pad printing machines are built around one of two basic principles of operation. Those two principles are commonly referred to as the "open principle" and the "closed principle".

Pad printing was initially developed around the open principle. Closed ink systems did not really appear as a viable alternative to the open inkwell until the late 1970's. Today the majority of pad printing machines use closed inking systems rather than open inkwells.

Basic Components of a Closed Ink System

Pictured below are the basic parts of a closed ink system.



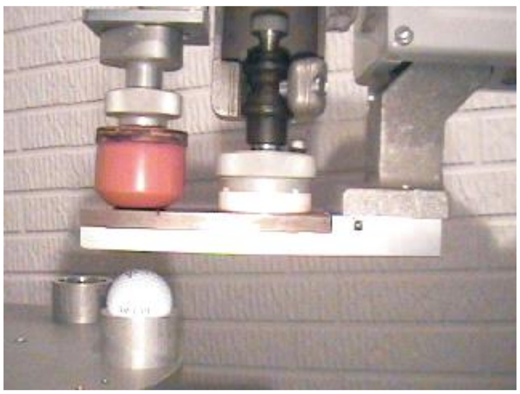
Closed Principle of Operation

The following six pictures illustrate how the pad printing theory is applied in the case of the closed principle.

Note that this machine actuates the cliche forward and backward. Other models may have the cup actuating instead of the cliche. In either case the end result is the same. Also note that for the purpose of obtaining a clear picture, I used this model of printer specifically because, with the guarding removed, you can easily see the basic components of the system and how they move throughout the process. <u>Never run a pad printer without the guarding in place</u>

Step One: Flooding. The image to be transferred is etched into the surface of the cliché. Once mounted in the machine the cliché is flooded with ink when the image is contained within the inside diameter of the inverted ink cup's doctoring ring. This is commonly referred to as being the machine's "home" position.

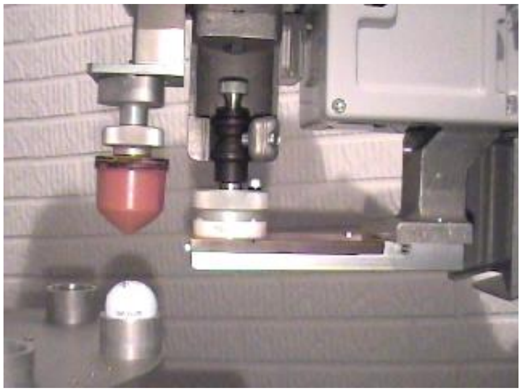
Step Two: Doctoring occurs in one of two ways with closed ink systems. Either the cliche actuates under the ink cup as in this example, or the ink cup actuates over the surface of the cliche. In either case the end result is that the surface of the cliche is doctored clean, leaving ink only in the etched image area. As solvents evaporate from the surface of the ink, the ink's ability to adhere to the silicone transfer pad increases.



Step Three: Image Pick-up The pad is positioned directly over the image area on the cliché, pressed onto the surface, then lifted away. The physical changes that take place in the ink during flooding will enable the ink to leave the etched image area in favor of adhering to the silicone transfer pad.

Step Four: Print Stroke As the pad is lifted away from the cliché and moves toward transferring the image, the ink on the pad's surface undergoes physical changes as solvents evaporate from the outside of the ink layer, making it tackier (increasing surface tension)

Step Five: Image Transfer The pad is compressed onto the substrate to transfer the image. The contour of the pad is designed to roll out onto the substrate's surface, rather than press flat against it, displacing air from between the pad's surface and the surface of the cliche and object.



Step Six: Pad Return. The pad lifts away from the substrate, assuming its original shape. When all the variables involved are properly controlled the pad should lift away clean and ready for the next printing cycle.

Closed System Benefits

Closed ink cups minimize the solvent evaporation problem and make doctoring more efficient. Try going fast with an open inkwell and you'll have ink flying all over the room.

Closed systems generally allow better process control since the inks are not directly exposed to the air. Solvent evaporation, the effects of temperature and humidity, and airborne contamination are all reduced in closed systems. Operators spend a lot less time fiddling with ink viscosity and complaining about the smell.

Closed systems also typically have fewer parts and require less ink, which translates in faster plate and / or color changes and faster clean-up.

Closed System Limitations

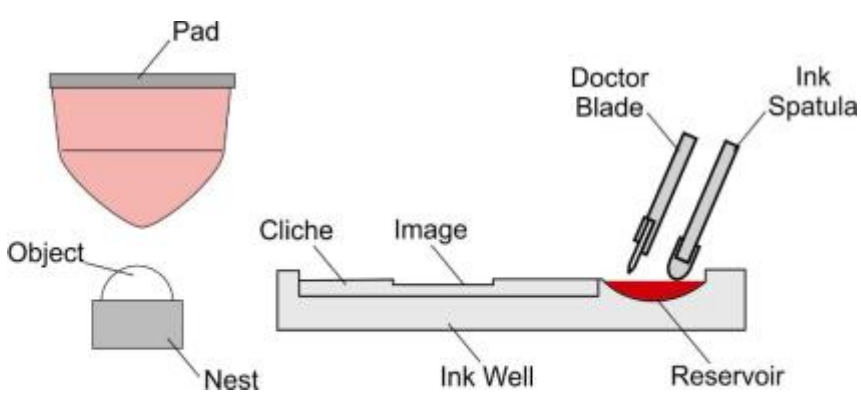
The drawbacks to a closed cup system are centered on the need for the cup to have a home position. On an open inkwell the doctor blade and ink spatula do not require a large amount of space. A cup, however, must have a place to rest when the image is exposed, thus effectively doubling the size of the plate necessary for a particular image. Furthermore, ink cups designs are usually proprietary, thus they can only be purchased from one source.

Since 2000 many companies have emerged in the industry offering "replacement ink cups for all major brands". A word of caution: using replacement parts [ink cups or doctor rings] from anyone other than the manufacturer of your machine will usually void any warrantee. We'll talk about ink cups more later in the book.

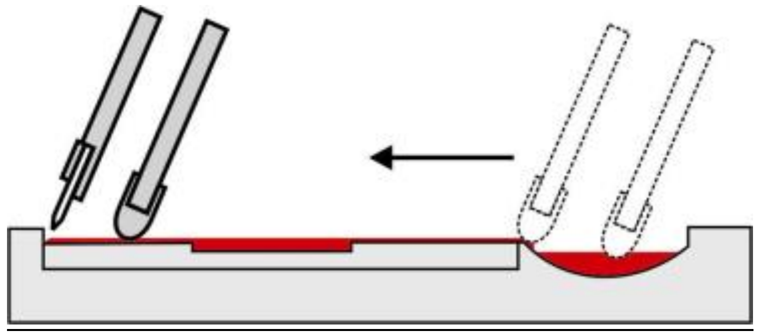
Open Systems

Open systems are pretty rare as of this writing in 2016, but it is still important to know how they work.

Basic Components of an Open Ink System

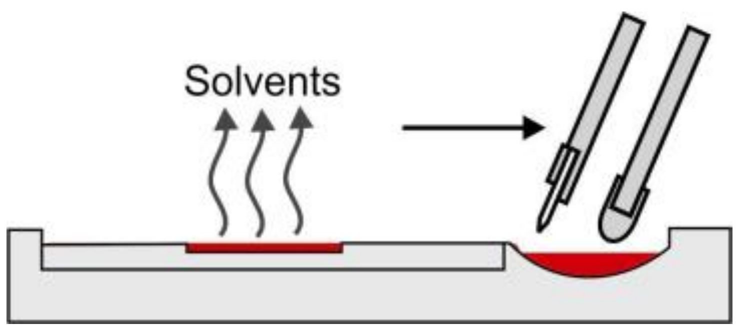


It was from this operating principle that the pad printing process originated. The following diagrams illustrate how the open principle works.

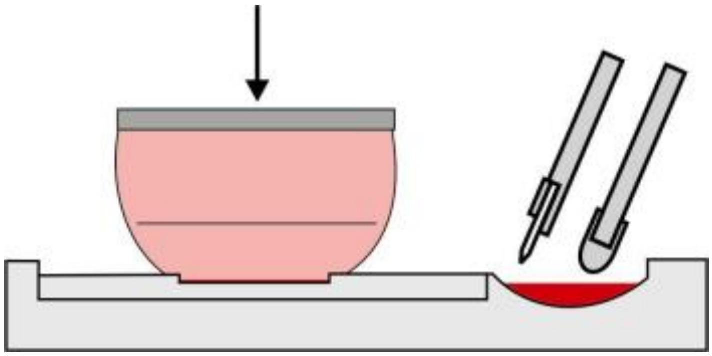


Step One: Flooding: The image to be transferred is etched into the surface of the cliché. Once mounted in the machine the cliché is flooded with ink by means of an ink spreader. This spreader may be a roller, a spatula, or even a brush.

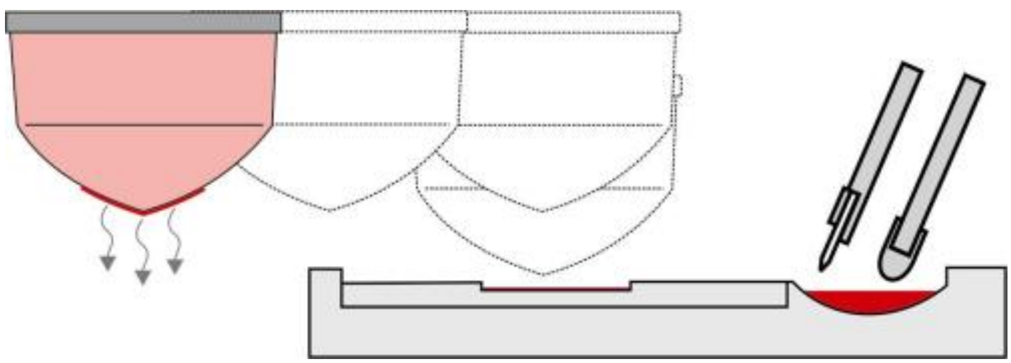
Once the carriage is at the front, forward position the ink spreader mechanism usually (but not always) actuates up, while the doctor blade actuates down into contact with the cliche surface.



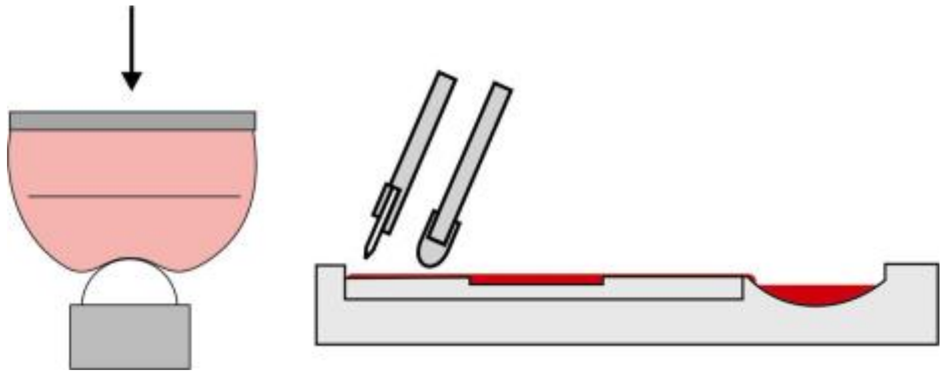
Step Two: Doctoring: The cliché surface is then doctored clean, leaving ink only in the etched image area. As solvents evaporate from the surface of the ink, the ink's ability to adhere to the silicone transfer pad increases.



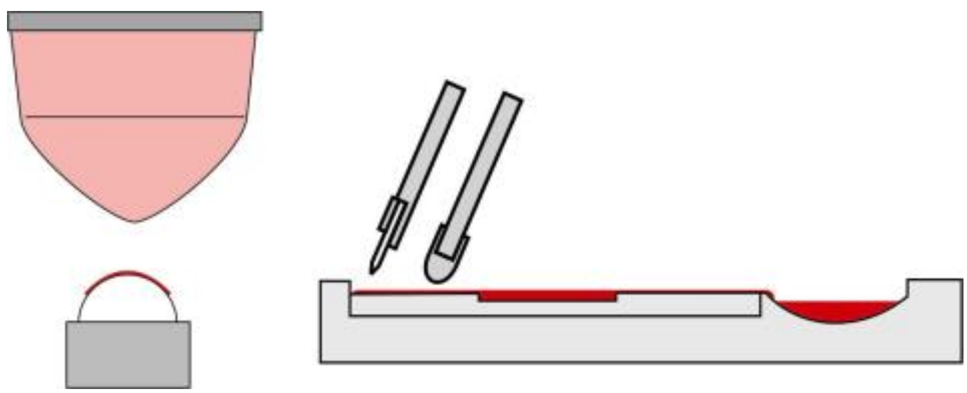
Step Three: Image Pick-up The pad is positioned directly over the cliché, pressed onto the surface, then lifted away. The physical changes that take place in the ink during flooding and doctoring allow it to leave the etched image area in favor of the transfer pad.



Step Four: Print Stroke. After the pad is lifted away from the cliché, the ink on the pad's surface undergoes physical changes as solvents evaporate from the outside of the ink layer, making it tackier (increasing surface tension).



Step Five: Image Transfer The pad is compressed onto the substrate to transfer the image. Even though the pad compresses considerably during this step, the contour of the pad is designed to roll out onto the substrate's surface, rather than press flat against it. A properly selected pad, in fact, will never form a zero degree angle of contact with the substrate. Such a situation would trap air between the pad and the substrate, resulting in the incomplete transfer of the image.



Step Six: Pad Release. The pad lifts away from the substrate, assuming its original shape. When all the variables involved are properly controlled the pad should lift away clean and ready for the next printing cycle.

Many people ask what benefits are to be gained by using one type of system over another. While the ratio of closed systems to open systems is today perhaps as high as 100:1, each type of system has its respective benefits and limitations.

Open System Benefits

Open systems allow you to use more of the cliché surface area for the image. This is because your image area is not defined by the diameter of the closed cup. They are also somewhat more versatile in that you can simply change the size of the inkwell and accessories, which allows you to use varying plate sizes and multiple colors. Travel to any contract decorating house (of which there are mysteriously few in the United States) and you will see a number of open inkwell machines at work. People who make their living from contract pad printing find them more flexible.

Open System Limitations

Open systems have definite drawbacks for the un-initiated because maintaining ink consistency is a constant issue. Remember that the entire basis for why pad printing works is the rapid evaporation of the thinner. In an open system the "not enough, oops, too much thinner" syndrome runs rampant. If the environment is uncontrolled the problem gets worse as swings in temperature and humidity wreak havoc on even the most carefully mixed inks.

3. Choosing the Right Decorating Process

Manufacturers decorate their products to differentiate them from those of their competitors. Often product designs are approved, marketing campaigns are launched, and expensive tooling is ordered without anyone ever confirming the design's feasibility with regard to the decorating process that has been specified.

This chapter will pair up some key design characteristics with the appropriate decorating process while identifying the benefits and limitations of one process versus another. Processes that will be discussed include pad printing, screen printing, hot stamping / heat transfer, in-mold decorating, piezoelectric DOD (drop-on-demand) inkjet and digital thermal transfer marking.

In researching this chapter one of the first things I did was create a "Plastics Decorating Matrix" which I sent it out to dozens of people within our industry. I chose both people that specialize in one process, and people with experience in several processes, and asked them for their professional opinions in rating the processes that I've mentioned for their suitability over a range of substrate materials, part and image characteristics, and sensitivity to conditions within the production environment.

While the responses were limited, they confirmed what I know from 25+ years of experience: very few plastics decorating applications have only one "right" solution. Each application is unique in some way, just as each process has benefits and limitations that play an integral role in determining whether or not it provides the "best possible" solution.

The following chart shows which processes my respondents felt were the best, good, poor or not applicable considering specific part characteristics. Keep in mind that this is a guide only, since part characteristics can sometimes be modified to better facilitate decorating with a specific process.

	Decorating Process						
Part Characteristics	Pad Print	Screen Print	Hot Stamp	Heat Trans.	In-Mold	Ink Jet	Digital Thermal
Flat	Good	Best	Good	Good	Good	Good	Good
Compound Angles	Best	Poor	Poor	Poor	Good	Poor	Poor
Concave / Convex	Best	Poor	Poor	Poor	Good	Poor	Poor
Spherical	Best	Poor	Poor	n/a	n/a	n/a	Poor
Cylindrical	Good	Best	Good	Good	n/a	n/a	Good
Raised Graphics	Poor	Poor	Best	Good	n/a	n/a	Poor
Recessed Graphics	Good	Poor	Best	Poor	Poor	Good	Good
Textured Surfaces	Good	Best	Good	Good	Good	Poor	Poor
Hollow	Best	Poor	Good	Poor	n/a	Good	Poor

Compound Angles, Concave / Convex and Spherical Parts

Pad printing has long been recognized as the process of choice for direct printing onto compound angles, concave and convex surfaces, and spherically shaped objects. This is largely due to the transfer pad's ability to pick up an image from a flat plane and conform to transfer it onto irregularly shaped surfaces with little or no distortion.

Alternatively, IMLs can provide a solution where run size requirements are larger and / or indirect decorating is preferred. IMLs, or pre-printed and / or pre-formed film inserts, are generally more expensive to produce, and may require that the artwork be pre-distorted. While IML enjoys (with exceptions) an advantage over pad printing for large image areas, it is generally not cost effective versus pad printing when the image only covers a small portion of the decorated surface.

Flat Parts, Raised and Recessed Graphics

Screen printing and hot stamping / heat transfer are generally the "go-to" processes for use in decorating flat parts. Screen printing being the obvious choice for areas of large coverage, and hot stamping / heat transfer being the obvious choice when small images are required and / or indirect methods are preferred. The following diagram shows how screen printing is accomplished.

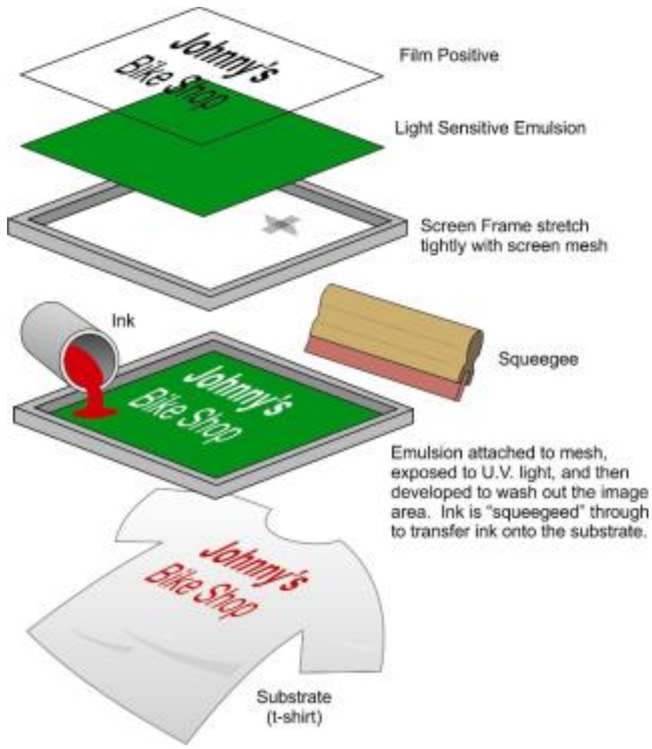


Illustration by John Kaverman

Hot stamping / heat transfer does have a distinct advantage in that substrates with low surface energies, such as polyethylene and polypropylene, do not require pre-treatment in order for the image to adhere. The following diagram illustrates how hot stamping is accomplished.

Hot Stamping Press

The following illustration shows the basic components of a hot stamping system.

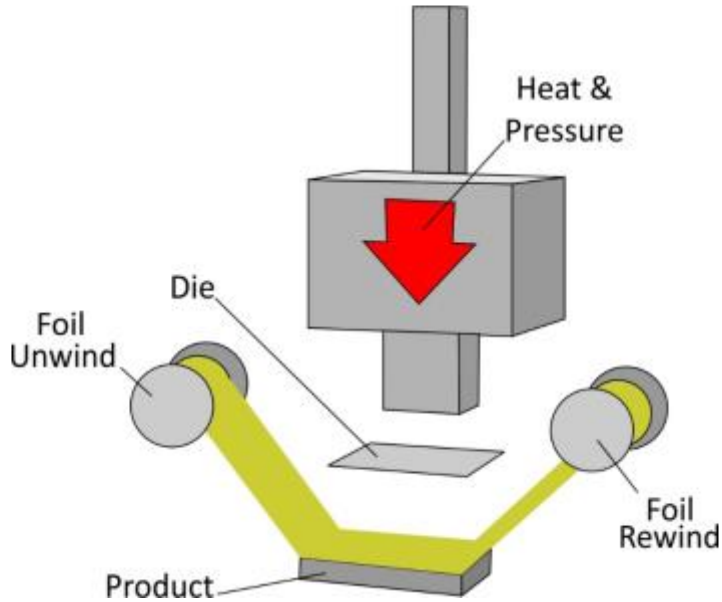


Illustration by John Kaverman

Additionally, hot stamping / heat transfer decorating is not affected by extremes or variations in temperature and relative humidity within the production environment.

Raised and recessed graphics are generally decorated via the vertical hot stamping process, unless there are surface irregularities in raised graphics, in which case a roll-on press is generally used.[3]

IML applications work best on flat part surfaces or on large radii. Long narrow images with pointed corners do not work very well because the force of the material flow in the mold tends to move the label out of position during molding.

Cylindrical and Hollow Parts

Cylindrical items such as 5 gallon paint pails are typically screen printed. Rotary pad printing is also useful for smaller format parts such as syringe barrels and closures, and can reach extremely high speeds (400-600 parts per minute), even with U.V. curable inks.

Photo- United Silicone

Heat transfers may also be applied to cylindrical parts. For coverage of less than 85 degrees, a curved silicone rubber die can be made to fit the curve of the plastic part. For coverage up to 360 degrees, transfers can be applied by rolling the parts under a flat silicone die, with pre-registered transfers sandwiched in between on a web.

Hollow parts, such as blow molded containers, are usually screen printed or labeled with pre-printed PSA (pressure sensitive adhesive) labels. For more rigid parts with smaller diameters and / or thicker sidewall constructions, hot stamping / heat transfer can be an alternative.

Hollow parts, such as blow molded containers, are usually screen printed or labeled with pre-printed PSA (pressure sensitive adhesive) labels. For more rigid parts with smaller diameters and / or thicker sidewall constructions, hot stamping / heat transfer can be an alternative.

Pad printing is becoming more widely used when hollow parts have complex geometries that are too difficult or impossible to screen print, label or dimensionally too unstable to hot stamp / heat transfer decorate. When pad printing hollow parts that are not dimensionally stable it is essential to inflate the parts equally, at each print station, to ensure registration of the image.

Textured Parts

Textures are almost always a gamble. In an attempt to find a correlation between characteristics of different textures and printability, I pad printed a series of sixty-odd black 'visual texture standard' plaques, provided by Mold-Tech. I used an automotive-approved, two component, white ink-thinned 15 percent by weight; a steel cliché with an etch depth of 23 microns, and a high angle, 9 shore (Scale C) transfer pad.

Each plaque was single-printed at one end and double-printed on the other, then allowed to dry per the ink manufacturer's recommendation. The plaques were then visually inspected for coverage under a uniform, non-directional (unfocused) light source at a distance of 18" for approximately ten seconds (per Ford Motor Company visual inspection procedure for automotive interior parts). Acceptance or non-acceptance was determined by the presence of any visible defect or void resulting from insufficient coverage of the texture.

The results indicate that the frequency of the texture plays a significantly larger role in achieving an acceptable print than the depth of the texture or the angle of the sidewalls. One texture having a depth of .0055" and 8 degrees draft was successfully single- and double-printed, whereas another texture that was only .0015" with 2.5 degrees draft couldn't be printed successfully at all. The difference was the number of peaks and valleys in the texture within the image area. The obvious conclusion: the higher the frequency, the lower the likelihood of acceptance.

Textures can be compensated for, however, by depositing more ink. That makes screen printing a great solution for flat or cylindrical parts. For large image areas and / or complex geometries, your only choice may be to apply IML technology.

	Decorating Process						
Image Characteristics	Pad Print	Screen Print	Hot Stamp	Heat Trans.	In-Mold	Ink Jet	Digital Thermal
Single Color	Good	Best	Good	Good	Good	Poor	Good
Multi-Color	Best	Poor	Poor	Good	Good	Good	n/a
Wet-on-Wet	Good	Poor	n/a	n/a	n/a	Best	n/a
Selective Data	Poor	Poor	Poor	n/a	n/a	Best	Good
Large Coverage	Poor	Best	Good	Good	n/a	n/a	n/a
Fine Detail	Best	Poor	Poor	Good	Good	Good	Good
Metallic Colors	Poor	Poor	Best	Poor	Poor	Poor	Good
Patterns	Poor	Good	Poor	Good	Good	Best	n/a
Spot Color	Good	Best	Good	Good	Good	Poor	Good

Image characteristics are a little harder to quantify than part characteristics, mostly due to the fact that many applications are comprised of a wide variety of different kinds of graphics; bold and finely detailed, metallic and matte, etc.

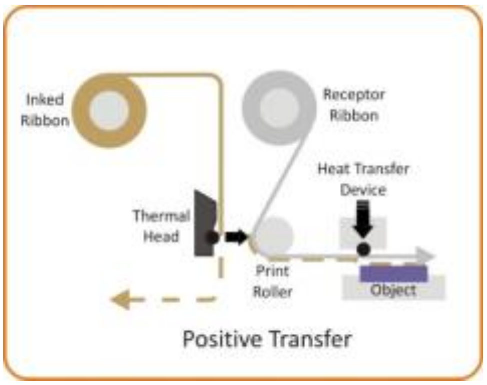
Wet-on-wet / Personalization

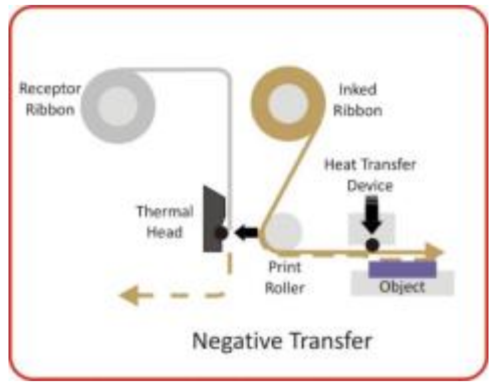
Piezoelectric DOD inkjet is the only process in the survey that received an "excellent", and it was for wet-on-wet. For short run CMYK and personalizing or serializing, you would have a hard time finding a better solution. With today's U.V. ink jet formulations, more and more advertising specialty advertising, small format signage and promotional marketing applications are going with DOD inkjet.

"Selective Data"

Selective data applications include serial numbers, 2-D matrix codes, bar codes and personal names. While digital ink-jet is most popular, digital thermal transfer marking is of parallel quality, and has superior durability by comparison.

Digital thermal "looks" like hot stamping, but it's not. In a classic hot stamping or heat transfer process you either have an image-specific die, or pre-printed (via screen, gravure, flexographic or digital printing methods) transfers that are applied to the parts using heat, pressure and time (hot stamping press). In the case of digital thermal transfer marking, each unique image (or lot of images is you're doing multiples-up) is generated digitally *from* a solid, colored "inked ribbon" *to* a "receptor" ribbon within the thermal transfer head, and then transferred as a whole using a roller or pad that has been heated to high temperature (see illustrations below).





Illustrations by John Kaverman

Multiple Color and Fine Detail

New generation YAG lasers, laser cliché materials and digitally controlled, multiple-axis pad printing systems in printers are producing lines only microns in width, and CMYK images with 1200 d.p.i. resolution, even on complex geometries. Screen printing provides nearly equivalent quality, as does IML.

Heat transfers are a viable alternative for those that don't wish to become printers. Transfers are generally manufactured using one of three processes: screen printing, rotogravure or flexography. Screen is very popular in that it allows for brilliant colors. Rotogravure provides superior resolution but is more attune to larger quantities due to the increased set-up time, and flexography is least expensive but does not provide the brilliance of screen printing or the resolution of rotogravure.

Metallic Finish

Hot stamping continues to be the process of choice for high gloss, metallic finishes like those found on cosmetics. In fact, hot stamping is the only process where the bright gold and silver metallic finishes found on cosmetic packaging can be produced.

IML is generally not recommended for applications requiring foils or metallic inks because they will not adequately maintain a static charge (required to stay in location within the mold) and because they can arc to the mold surface, causing pitting.

Large Coverage

Screen printing, and screen printed IMLs have a commanding lead when large areas of coverage are required. Because screen printing is capable of depositing an ink film thick enough to gain tactile qualities, it is especially popular for direct label applications. Pad printing only lays down about 20% the ink film thickness of screen printing, and is limited to a relatively small image area by comparison. Hot stamping / heat transfer requires about 500 p.s.i for solid coverage, so with each square inch the image increases the less cost effective it becomes. For hot stamping applications over 15" square, roll-on is recommended.

Patterns

Patterns like camouflage and carbon fiber are commonly reproduced using heat transfers (for larger areas) or ink jet (for smaller areas). For "all over" coverage on 3-dimensional parts the most popular method is actually water transfer printing technology, a.k.a. hydrographics (not on the matrix).

In water transfer printing, the fixture part is dipped through the inks, which are printed on a water soluble carrier and then floated on the surface of the water.

As the parts are immersed the displacement of the water carries the inks around the 3-dimensional shape of the part.

Spot Color

There are a number of processes that are good at laying down "spot color" such as specific Pantone Matching System (PMS).

Ink jet does not receive a high recommendation for one color, spot decorative printing however, nor do digitally printed heat transfers, because with CMYK processes, spot color reproduction can be a challenge.

Sensitivity to Environment

All wet ink film transfer processes are affected by extremes and /or variations in temperature and relative humidity within the production environment. If a potential supplier says otherwise, run in the opposite direction. The feeding and registration of heat transfers and IML labels can also be affected by the environment. In fact, the bulk of transfers and IML labels should be stored in a climate controlled environment, with only enough labels for about ½ a shift brought to the press that is out on the floor in an uncontrolled environment.

If you really want to have the best possible control of your decorating process, control your environment and keep it, and everything inside of it, clean.

Substrate / Resin Considerations

In some applications the substrate will influence, if not dictate, which process you should use.

For direct printing (pad, screen, ink jet) the substrate must have sufficient surface energy in order for the ink to adhere. For example, polyolefins (polypropylene, polyethylene) should be pre-treated to a minimum of 38 Dyne / cm^2 .

> Dyne Levels: 32 Dyne / cm^2 to 54 Dyne / cm^2 is the total [printable] range. 42 Dyne / cm^2 or better is widely considered to be optimal. For best results refer to your ink's technical data sheet.

Like direct printing processes, hot stamping / heat transfer requires that you use foils or transfers having ink that is compatible with the substrate material.

Some resins used in IML molding are more user friendly than others: polycarbonate and nylon resins present challenges because their melt-point temperatures are higher. On the other hand, PP and PE are easier to handle due to their lower melt points. In general, the insert and backing resins do not have to be identical, but they must be compatible. If not, then a special heat-activated adhesive must be used to ensure inter-coat adhesion.

Environmental Impact

While the proponents of any process with identify theirs as being "greener" than the next, all decorating processes create waste in some form, because none of them are 100% efficient. Most decorating processes can be made "greener" by:

- Utilizing electro-mechanical drive systems instead of less efficient pneumatic drive systems, or at least increasing the efficiency of their compressed air delivery systems.
- Updating their film, screen, cliché and die making processes to use modern materials and more environmentally friendly chemistry, or by utilizing computer to cliché / screen technology.
- Using more environmentally friendly ink systems whenever possible (i.e. water based or U.V. instead of solvent based systems).

Summary

Rarely does a given plastics decorating application have only one "right" solution. By carefully considering each application's requirements, clearly communicating them to decorating process suppliers and specialists, and thoughtfully confirming feasibility through testing and sampling, you can successfully identify the most efficient solution possible.

Chapter 3 Sources:

1 **In-Mold Decorating with Pre-Printed Film Inserts**. Ann Marie Lentz. *Plastics Decorating*, Oct.-Nov. 2010

2 **Ins and Outs of Hot Stamping v. Heat Transfer.** Keith Hillestad. *Plastics Decorating*, Apr.-May 2009.

3 **Overcoming Challenges when Applying Heat Transfers**. Staff. *Plastics Decorating*, Apr.-May 2004.

4 **Pad Printing on Textures Surfaces**. John Kaverman. *Plastics Decorating*, Jul.-Aug. 2007.

5 **Ask the Expert: Digital Heat Transfer.** Matt Regan. *Plastics Decorating*, Apr.-May 2011.

6 **Ask the Expert: Water Transfer Printing Technology.** Mike Richards (TWN Industries, Inc.) *Plastics Decorating,* Jan. – Feb. 2008

7 **IML Solutions: Five Experts Share Advice.** Renee Varella, *Plastics Decorating Special Report*, Apr.-May 2011.

8 **Green Solutions for Pad Printing.** John Kaverman. *Plastics Decorating,* Jan. – Feb. 2011.

Thanks to everyone that contributed their ideas and opinions to this chapter. Special thanks to Ulrich Auerswald, Jeff Morris of RUCO U.S.A., Lynn Gulch of Monroe Products LLC, Brian Heus of Emerald Corporation and Trent Pepicelli of Innovative Marking Systems.

4. Pad Printing Machines

There are many types of pad printing machines that apply either the Open or Closed Principle. Most pad printers pick up and transfer the image vertically as pictured below. These are commonly referred to as *standard, or standard vertical* pad printers.

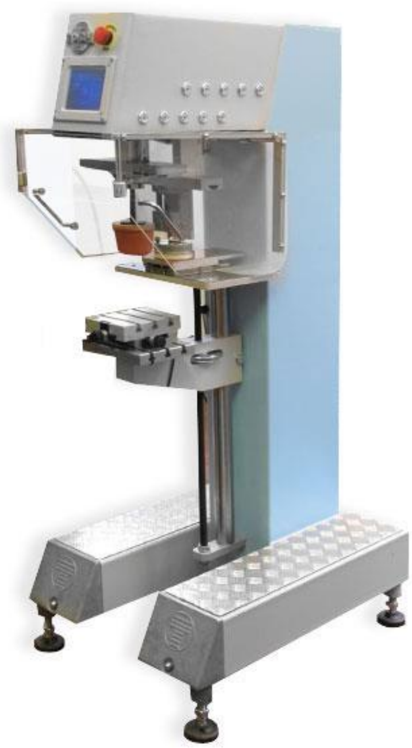


Photo: TOSH

Variations on Standard Vertical Machines

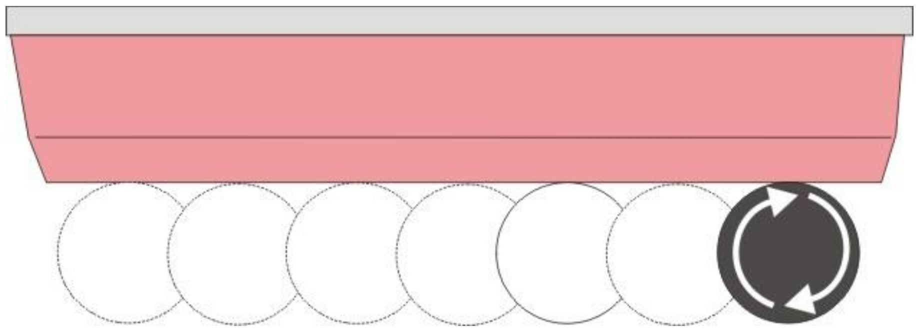
A few manufacturers modify the ink cups in standard vertical machines by equipping them with inflatable diaphragms that I mentioned at the end of Chapter Two. Machines using these cups are usually mounted to automated systems where parts are printed on several different sides in one cycle. While these cups are handy in that they allow some standard vertical machines to print on any angle they can be tricky to set up and maintain, and their maximum diameter rarely exceeds 60 mm.

Another variation on standard vertical design is the carousel machine. Synchronized rotation of separate cliché and pad mechanisms allows for multiple color printing on a stationary substrate. The pad "carousel" turns. This allows multiple pads to pick up images from multiple clichés, then transfer the images to a stationary part.

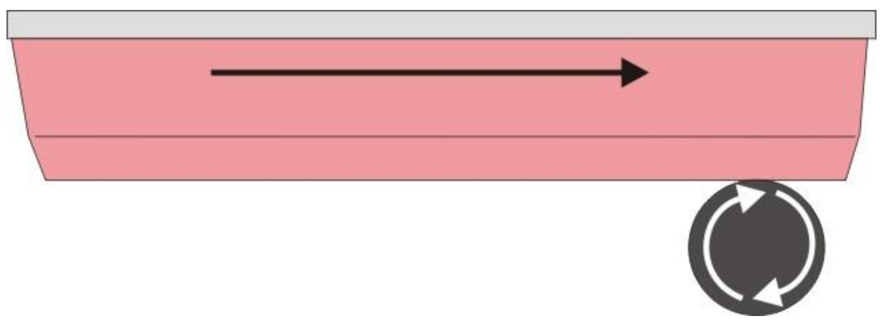
Photo: Tampoprint

Roll-on Printing with a Vertical Machine

Standard vertical machines can also be modified to print 360 degrees around a cylindrical object in certain applications. This can be accomplished two different ways. In both cases the pad picks up the image and travels to the end of the print stoke (or down position). The first method (illustrated below) rolls the cylindrical part, nested on a mandrel, along the length of the pad by means of a gear. The second method (also illustrated below) shuttles the pad across the top of the part.



Part rolls under stationary pad.



Pad traverses while part rotates.

Illustrations by John Kaverman

Horizontal Machines

Another variation on standard vertical design is the *horizontal* pad printer. Machines of this type flood, doctor, and pick up like a standard vertical machine, then actuate to print horizontally. (See picture below.) These machines are rarely seen in production anymore, and are not very time efficient in any case because they have very little printing force.

Photo: TOSH

More often, manufacturers use machines with actuating clichés (like the one used to illustrate the Closed Principle of Operation in Chapter 2) on its back, so the pad is stroking horizontally. This is beneficial over the old "vertical to horizontal" idea, since the pad only has to move in one axes (horizontally), as opposed to two. That means significantly less "wobble" of the pad during the cycle, which is a good thing since wobble means image distortion and / or poor registration.

Sliding Ink Cup Machines

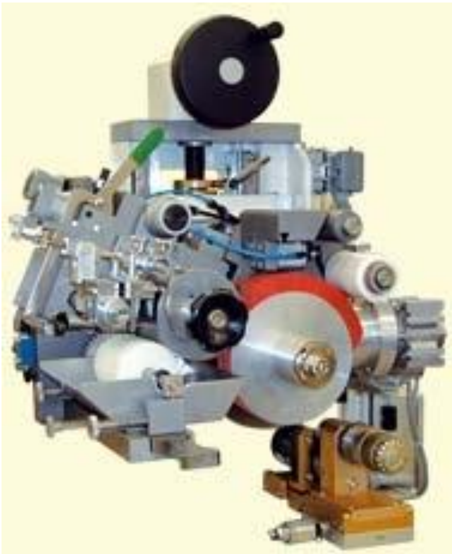
Example "sliding ink cup" pad printing accessory. www.padprinters.com

One of the more popular closed system evolutions is the *"sliding ink cup"* machine. These machines feature long, narrow clichés that are mounted in the X-axis, or perpendicular to the axis along which the pad travels. (See photograph above). Sliding ink cup machines allow wide images to be printed with a closed system. They work great for printing things like catheters, rulers, hoses and sporting equipment. Larger versions than the one shown above, such as those manufactured by TOSH of Italy, are used to print larger format images such as those found on molded nylon engine covers in the automotive industry.

Rotary Machines

Rotary pad printers come in two varieties. There are vertical and horizontal rotary machines. Either type is capable of printing on flat or cylindrical objects using cylindrical "drum" clichés and round transfer pads.

Vertical Rotary Machines



Vertical Rotary. Photo www.tampoprintusa.com

A vertical rotary machine can print flat surfaces (like the top of bottle caps) when the objects to be printed are moving along underneath the rotating pad. In the photo above you can see a part nesting on a gold, anodized mandrel. In applications such as this several rows of parts can be printed simultaneously by using a drum cliché with multiple images, and multiple pads.

Vertical rotary machines can also print cylindrical objects by any one of several methods. Single objects can be nested on a mandrel and shuttled to locate bottom center on the pad. The part is then rotated during image transfer either by the mandrel being gear driven, or by the force of the transfer pad.

Cylindrical objects (for example, pencils) can also be conveyor fed along under a vertical rotary pad printer for 360 degree printing as illustrated below.

Horizontal Rotary Machines

Horizontal rotary machines can print on flat or cylindrical parts that are vertically nested. The next illustration shows cassette tapes being printed on two sides. Cylindrical objects such as lipstick canisters and syringe barrels may also be printed using this method, with much better image resolution and contrast than offset, the most popular competitor to pad printing for small diameter objects.

In 2010, Tampoprint, Germany introduced their Rotary Flow machine, a new, high speed, horizontal pad printing system for syringes. That machine is capable of printing up to 24,000 syringe barrels per hour, with U.V. curable inks.

Manual Machines

Example “manual: pad printer. Google Images

A few manufacturers offer small, manually operated machines. Manual machines feature a hand-operated slide with a pad at one end and an inkwell at the other. Some manual machines have simple, cam operated doctoring systems that automatically doctor the cliché when the operator slides the carriage, while others require the operator to actuate a lever connected to the doctor blade assembly with one hand while sliding the carriage with the other hand.

Up until about 2003, manual machines use the open principle, however sealed ink cup versions are now more popular.

These machines are suitable for very small, very low volume printing and hobbyists, but not for volume production.

Larger images (more than a couple square inches) are difficult to print clearly because the amount of energy required for compression of a pad large enough to accommodate an image of that size isn’t easy to generate with one arm.

Some manual machines can be “upgraded” to use a pneumatic cylinder for compression, however the value of “upgrading” a manual machine is negligible at best.

5. Popular Machine Drive Systems

Pad printers are powered by several different types of drive systems including: electro-mechanical, stepper motor driven, electro-pneumatic, electro-hydraulic, pneumatic, and manual.

Electro-mechanical

Electro-mechanical machines are electronically controlled cam driven machines. This type of machine is generally most expensive up front, and tends to lack some adjust-ability. Electro-mechanical drives are extremely consistent regardless of machine speed and print mode. (i.e. single or double print, etc.) These machines also have little difficulty compressing pads of any reasonable size, regardless of hardness. If you want to run critical parts fast and can justify the cost, this is the way to go. Since air is not necessary there is no need for an air compressor. This can translate into lower operating costs and less noise.

Stepper Motor Driven

Stepper motor drives have programmable adjustments for each individual stroke for both length and speed. A stepper motor basically translates 360 degrees of motor rotation into a given number of "steps". The operator can then program the number of steps he or she wants the machine to travel. These machines operate with little or no vibration, and are typically very quiet. As is the case with electro-mechanical machines, no air is necessary. Therefore, while these machines may be more expensive than an electro-pneumatic or pneumatic machine up front, the costs of operating it may actually be lower.

Electro-pneumatic

Electro-pneumatic machines are electronically controlled air driven machines. The majority of the machines in the industry today are of this type. Less expensive to manufacture, machines with this type of drive are quite reliable provided you are operating with clean, dry air at the proper pressure. At high speeds some pneumatic drives can have difficulty with consistency from print to print, especially in multiple print modes. This is usually due to the pneumatic cylinders not having enough time and / or air pressure or air volume in between cycles to completely "re-charge". Sometimes the addition of accumulators can alleviate this problem.

Pneumatic

Fully pneumatic machines are somewhat rare, and usually limited to closed systems. (I've seen a fully pneumatic pad printer that wasn't a closed system.) Less expensive still than their electronically controlled cousins, these machines are best applied to automations where they can run all day without stopping. One special benefit of fully pneumatic machines is that they are explosion resistant due to the lack of electronics.

Clean, dry air is important with any air driven equipment, electronically controlled or otherwise. Wet, excessively oily and dirty air can significantly reduce the life of the machine. Most pad printers require a constant air pressure in the ballpark of 85-100 P.S.I., or approximately 6 Bar. As I mentioned earlier, the volume of air readily accessible can be of importance, especially when double printing, or when running a pneumatic printer and a pneumatic conveyor table or shuttle off of the same airline.

Regarding Pneumatics

The majority of pad printing machines feature electronically controlled pneumatic drive systems. Because compressed air is one of the most expensive sources of mechanical energy in the industrial setting, it is more energy efficient, and therefore less expensive, to use pad printing machines that feature an electromechanical drive.

While compressed air is a versatile tool, running air compressors uses more energy than any other equipment. Air compressor efficiency is the ratio of energy input to energy output. Many air compressors may be running at efficiencies as low as 10 percent.

Consider the cost of the electricity used to generate the compressed air. The average cost for electricity in the United States in 2009 was $ 0.1002 per kWh1. This example utilizes a Tampoprint Model SIC 90 machine with a compressed air consumption of 2.7 NL (normal liters) per cycle. If the machine is working at an average rate of 1,000 cycles per hour, it will require 2,700 NL (about 950 cubic feet per hour) at 6 bar (90 p.s.i).

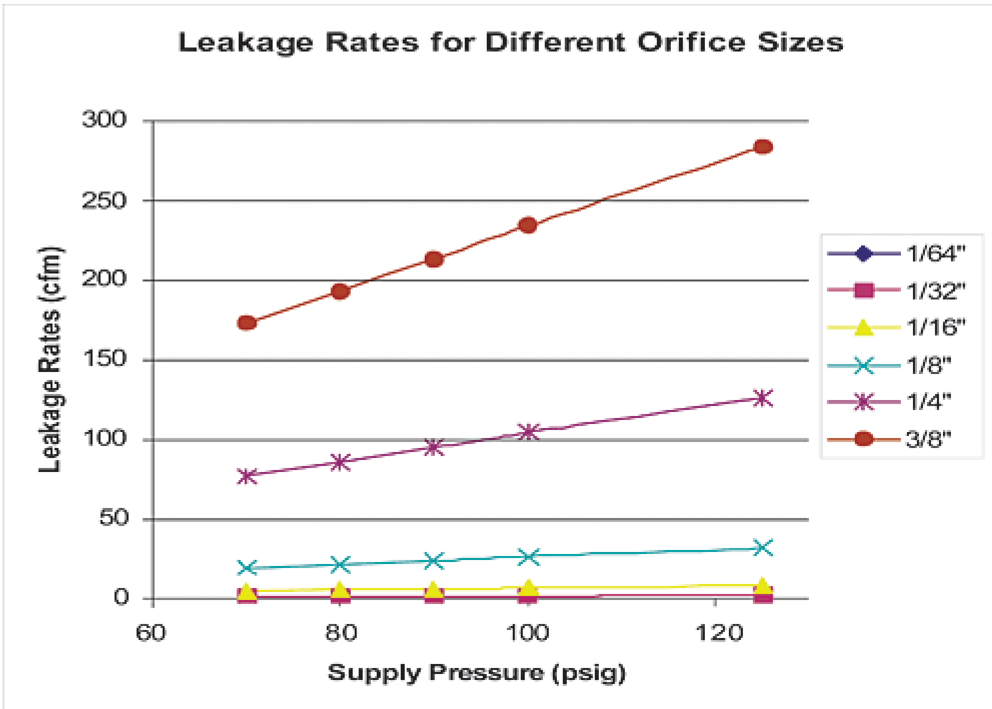
Maintaining that pressure at the machine with an oil injected rotary screw compressor would require, on average2, about 15 kW. By comparison, an electromechanically driven machine (such as the Tampoprint Model Hermetic 911) consumes a mere 1 kW in performing the same amount of work.

If the air delivery system was 100-percent efficient, and cost was calculated using the average industrial cost of electricity, the electromechanical machine would save $2,024.00 per year. If the air delivery system is only 25-percent efficient, the electromechanical machine becomes $ 3,650.00 less expensive to operate annually.

Increasing Compressed Air Delivery System Efficiency

If switching to electromechanical machines is not an immediate option, a lot can be done to increase the efficiency of the compressed air delivery system. Four aspects of compressed air systems are crucial to efficiency:

Choose a storage tank that can accommodate the needs of the system and prevent pressure from dropping below the minimum. This is especially important when there is peak demand in production, such as when running continuously and when running several machines off the same compressor. The common response to machine malfunctions due to a decrease in air pressure is simply to increase the system pressure. The energy wasted by increasing the system pressure could be saved by increasing the size of the storage tank or by installing smaller accumulating tanks near the pad printers themselves.



Delivery lines that are too long, too narrow and have too many sharp turns are inefficient because they result in significant pressure loss. The solution is to place the compressor and/or storage tank closer to the pad printers, use larger diameter delivery lines and avoid sharp turns and loops

Cooler air requires far less energy to compress than does warmer air. Reducing the temperature of intake air by moving the compressor air intake outside (in cooler climates) or using an intake air chiller can substantially reduce the amount of energy required for compression.

Maintenance can have the most significant impact on efficiency. The number one source of energy loss in a compressed air delivery system is leakage. Although leaks often are very small, significant amounts of air can be lost. The graph on page 28 illustrates the amount of air lost through different orifice sizes.

Finally, it is important to include the replacement of compressed air delivery system filtration media in a preventive maintenance program.

Manual

Manually operated machines are small and inexpensive. Some models have cam operated doctoring mechanisms, and some don't. This feature is well worth the extra few hundred dollars they usually cost. Image sizes are limited to a few square inches since compressing a pad any larger would require Herculean strength. These machines are a nice alternative to starter level electro-pneumatic machines for those who are experimenting with pad printing, or who are doing small volume jobs that aren't critical. Some manufacturers offer trade-in deals when upgrading from manual to automatic machines.

Electro-hydraulic

Electro-hydraulic machines are very rare. These machines are usually more expensive than even electro-mechanical machines to manufacture. While these machines are slow, they can supply a lot of compression for those gigantic images that absolutely can't be printed by any other means.

Chapter 5 Sources:

1 **U.S. Energy Information Administration**, Electric Power Monthly. January, 2010.

2 **Don't Err with Compressed Air**, David M. McCulloch, Chemical Processing, 2008.

3 **Energy Efficiency in Air Compressors**, N.C. Division of Pollution Prevention and Environment. Assistance, January 2004.

6. The Benefits of Stepper Motors

As a self-professed pad printing geek, I love technology. Technology tends to advance in fits and starts, and pad-printing equipment is no exception. New machinery is developed by manufacturers either as a means to overcome specific technical hurdles or in response to competitive pressures. On the following pages, we'll look how the old technology of pad-printing has learned new tricks when confronted with both of these issues. And we'll explore how improved equipment designs are opening doors for the pad-printing process in industrial-imaging applications. In particular, we'll consider large-format applications involving consumer appliances, where new pad-printing machines are making the technology viable as an alternative to in-mold decorating.

To understand how pad-printing presses have evolved for these applications, it's best to start by examining trends in consumer product design, particularly in Europe (where the vast majority of pad-printing equipment is also manufactured). One of the most influential trends has been the dramatic change in the design of control panels used on new European appliances, such as washing machines, dryers, stoves, dishwashers, etc.

In the past, appliance panels were typically flat. But in recent years, designers have gone to great lengths to incorporate more attractive curved surfaces into their panels with the aim of differentiating their products from those of competitors.

To make matters more interesting, new panels often feature dozens of multicolor graphics across their surfaces, and the panels may be as wide as the appliances on which they are mounted.

This design trend is only beginning to edge into the US marketplace. But the pad-printing equipment developed to address it has implications beyond just the home appliance market. Large-format, multicolor pad-printing capabilities hold promise for a broad range of applications that have yet to be explored.

When curved and contoured panels emerged in Europe, the only available options for decorating the parts were to use in-mold decorating technology or turn to conventional pad-printing equipment. Neither option is ideal, especially considering that the same panel might be used on products sold in a dozen different countries with a dozen different language requirements. For the decorator, this means the order isn't really one single project, but a collection of short-run jobs.

Adding to the difficulty is the fact that many appliance OEMs demand just-in-time manufacturing on their orders. Under these circumstances, the make-ready required for in-mold decorating and the frequent press changeovers necessary with conventional pad-printing equipment simply aren't practical.

But with the latest generation of pad-printing machinery, it is no longer necessary to perform multiple setups, use multiple machines, or rely on inaccurate conveyors to move large-format parts through a multicolor pad-printing line. Today, pad presses are available that can print the entire length of large panels with as many as ten colors and deliver more than 60 impressions/cycle to achieve production rates of several hundred parts per hour. The secret behind this new level of performance is found in the stepper motor and the digital systems that drive it.

Stepper motor technology in pad printing

Stepper motors have revolutionized the pad-printing industry in Europe. In basic terms, a stepper motor is digitally controlled electric motor that doesn't rotate continuously, but moves in small increments or steps of a predetermined distance (measured in degrees). Stepper motors are controlled by computer programs or similar digital control systems that tell the motor how many steps to move and in which direction. Using this strategy, the motor can be used to repeatedly and precisely control the motion and position of any mechanical apparatus to which it is attached.

A stepper motor can be programmed to travel specific distances at specific speeds. When applied to pad printing, stepper motor technology allows the machines to precisely control the position (linear or rotational) and motion (speed, direction, etc.) of parts along multiple independent axes.

This programmability means better process control, even for someone producing a simple single color application in which parts are manually loaded and unloaded from the press. And in multicolor industrial applications, pad presses driven by stepper motors can provide a faster and less expensive alternative to in-mold decorating or direct screen-printing.

Before steppers, pad presses were either driven with simple pneumatic cylinders, or electromechanical devices that could only travel a non-adjustable distance. Sure, a press might employ a mechanical stop or a limit switch, but we couldn't move that stop or switch during a print run to vary the distance the machine moved in any particular direction. With a stepper motor, however, we can select the exact distances we need the print head and part to travel in each axis and vary these distances over the course of the print run if necessary.

The picture below illustrates one scheme for using a stepper-motor-driven pad press and part-conveying accessories. This sample application represents a four-color appliance panel job that in which the panels are conveyed along two axes (Y axis plus rotation) of motion during the printing cycle.

Photo - Innovative Marking Systems

In this example, the operator loads from the far left side of the linear indexer, so the part travels right / left along the Y axis via a linear indexer and in the R axis (rotation) via a rotary table, while the pads travel in / out along the X axis, and up / down along the Z axis. On the machine shown, the accuracy of the image placement in each axis is +-0.05mm

This isn't our only option on a press driven by stepper motors. We could also reprogramming the press to employ a two-step program and place a pair of images on each cliche, effectively doubling the number of graphics we can apply during the print cycle.

Stepper motors that drive the pad assembly can be programmed so that each pad picks up images from different locations of the clichés at each stage of the print cycle. By "stacking" images on the clichés from front to back, we could repeat the cycle we just illustrated using secondary image pickup locations. Depending on the size of the clichés used, this approach could work with even a greater number of images per cliche, allowing dozens of images to be printed during the same cycle.

What if the press doesn't have enough space in front of or under the clichés to accommodate long parts? To solve this problem, instead of using two linear indexers, we replace one indexer with a stepper-motor-driven rotary table. By indexing along the X-axis and rotating the part, we can print longer parts. For example, images 1-3 may be at one end of the panel, which is then rotated 180° to allow printing of images 4-6 on the other end.

If an application requires that you index in both X and Y directions, as well as rotate, we can put the second linear indexer (for the Y-axis) back on the press and mount the rotary table on top of it.

If we're working with more difficult three-dimensional parts, other handling system can also be employed. For example, a small rotary fixture (also stepper-motor driven) can be mounted vertically to a linear indexer. The part can be easily rotated to allow placement of multiple images around its entire circumference.

It is not uncommon for owners of stepper motor driven pad printers to have several different part conveying accessories on the shelf to accommodate a range of different applications and movement schemes. With today's user friendly digital operator interfaces, reprogramming the press for these accessories is simple and straightforward, allowing the machines to be easily reconfigured. Some European printing operations have developed routines that allow them to print as many as ten colors along six axes of motion, with over 60 impressions/cycle.

Today the most technologically advanced pad printer available is the TOSH Logica -08 Multi-format. This machine can print on up to five sides of a part in up to as many as ten colors, with as many as sixty impressions programmable in a single printing cycle. In Europe this machine is used extensively to print high-end collectibles such as toy trains, airplanes and cars. Additionally, this printer sees duty in the appliance industry.

Other benefits of stepper-driven pad presses

Besides supporting a broad range of part conveyance accessories motion sequences, pad presses driven with stepper motors also allow users to employ combinations of open inkwells, sealed ink cups, and varying cliche sizes in a single setup. The first image might be very small, requiring only a 60-mm (diameter) ink cup, whereas another image in the sequence may be 215 mm wide and require a 250-mm open inkwell. Even though all the clichés are doctored simultaneously on such a system, the use of stepper motors and specialized ink cups and/or doctor blade combinations allows the operator to use only the cliche sizes needed.

What about registration? Most stepper-motor pad-printing machines come with prepress equipment specifically designed to "preregister" films to clichés before they are exposed with the image. Typically, polymer clichés are used that are pre-punched with holes that correspond to pin-registration systems. The films are then aligned and punched with registration holes so that they align precisely where they're needed on the clichés. The machine components driven by stepper motors generally maintain tolerances of +/-0.001 mm.

To reduce changeover times, some presses allow the entire cliche platform to be rotated or completely removed from the machine for cleaning or replacement. By having spare cliche platforms and accessories available, changeover can take as little as 15 min for applications that involve as many as ten colors.

Dozens of other applications are also good targets for the technology of stepper-driven pad presses. Bezels, for example, can benefit from these machines and their ability to support larger part sizes than conventional pad-printing presses. Just consider the variety of products that may require graphics on their bezels, such as computer monitors, home video products, and other electronic devices. Medical-device control panels are another large but untapped market that has potential for shops using multi-axis pad printing equipment. And the list goes on with everything from automobile dashboard components to toys.

Labor reduction is a key justification for adopting stepper-driven pad presses. These labor savings are realized primarily by interfacing the machines with other elements of an automated production line. Because they are stepper-motor driven, the pad presses can be easily connected with the programmable logic controllers and computers that drive other systems, creating an integrated manufacturing system that be controlled through one operator interface.

Stepper motor technology also allows machines and part-conveying accessories to be easily integrated with non-print-related automation. Picture a part-handling robot and a stepper pad-printing system configured with a plastic-molding machine. When the mold opens, the robot rapidly removes two bezels that were just formed, placing the parts, one at a time, on a rotary table. The table indexes to print the first bezel, then again to print the second. While the second is being printed, the first is being dried with a hot-air dryer that is also integrated with the system. As the parts leave the dryer, the robot picks them up and deposits them in a package, which is sealed and whisked off by conveyor to the shipping department. By eliminating several material-handling steps, these machines working together can mold, convey, print, dry, and pack more bezels than a team of human workers using conventional production methods.

The Future is Now

Orchestrated by the programmable logic system, the motions of a stepper-motor press are fantastic to see, and the speed at which complex printing jobs can be processed becomes instantly apparent. Our first exposure to this technology occurred at a tradeshow in Milan, Italy, where we watched in fascination as a stepper-driven pad press printed toy train cars on five sides using a combination of open inkwells and sealed ink cups. The experience was like being a UFO geek with a day pass to Area 51.

The transition of pad printing from a labor-intensive specialty printing process to an automated industrial decoration method has been made possible by advances in many areas, from computer-based filmmaking and photopolymer clichés to self-regulating inking systems and digital controls. The introduction of pad presses driven by stepper motors adds even more capability to a process already sought out for its versatility. With this technology, industrial printers can provide an efficient and accurate decorating method that supports both high-volume, high-speed production and short-run, just-in-time applications.

7. TOSH: The Advantage is Built In

If you've taken the time to read the preceding chapter about the benefits of stepper motor technology, I would like to thank you personally.

My name is Trent Pepicelli and I've been the guy in charge telling the USA about TOSH for more than a decade. TOSH pioneered the use of stepper motor technology in the 1980s, and today is the undisputed leader in the use of stepper motor technology within the pad printing industry.

If you were expecting a dry chapter of facts and figures alone, I apologize. There is plenty of technical info below, but at the heart of it, this document was born from my passion about pad printing and the TOSH equipment that it has been my life's work to sell, service and support.

Since the first time I put my hands on a piece of TOSH equipment more than a decade ago I knew that I'd found something special. I've sold other pad printing equipment and various types of assembly machinery, but I have never worked with something that was so elegantly designed. TOSH machinery combines speed, flexibility and power unlike any other pad printing equipment I've seen before or since. Every aspect is designed with purpose and function in mind.

Over the intervening years I've worked on thousands of applications with customers whose skill levels range from expert to non-existent. I've answered the question "Why should I buy your machine?" at least a thousand times.

The fact is that there are hundreds of reasons to trust your production to a TOSH machine. With this document I've tried to create an exhaustive list of those features that put us head and shoulders above our competitors. When you've had a chance to review them I hope that you will be able to step back and see that our equipment is more than the sum of its parts. It has been designed from the ground up without compromise. That is the true TOSH advantage.

Just the Facts

Each piece of TOSH equipment is conceived, designed and built as a modular building block. There are no uni-tasking machines in the product range. Individual components can be combined in various combinations to achieve a wide variety of tasks. All equipment has a clear upgrade path in terms of speed and flexibility. The rigor of this design philosophy results in elegant design solutions that satisfy a broad range of customer demands. There are plug in solutions for your application, we do not need to re-invent the process for you, nor do we need to force a marginal solution because our equipment doesn't have the flexibility to do the job that needs to be done.

Here are the advantages that are built in to every TOSH machine:

Cast Aluminum Alloy Body

TOSH designers prefer that every aspect of the machine serve its final purpose: printing. This includes the basic chassis of the machine.

One of the key aspects of accurate, high quality, high speed printing is rigidity. Torque, whip and vibration cause distortion. Torque, whip and vibration force the operator to slow the machine down. In essence, these factors require you to baby the printing process.

By employing a tough as nails aluminum alloy body TOSH starts off on the right foot. Typical pad printers use a machined interior skeleton and then cover everything with a bent metal box. Every gram of material that goes into a TOSH machine serves a purpose. What purpose does a sheet metal housing serve? Sheet metal is prone to feeling the effects of torque, whip and vibration. A heavy duty machined casting eliminates these problems.

All Electric Drive and Function

Every piece of TOSH equipment is all electric. No compressed air is necessary to run any of our print heads or conveying accessories. There is more information related to stepper motors and precision control below, but simply focusing on the use of electricity instead of compressed air is of significant value.

Start with the simplicity of a single plug. As long as you have electricity you can run TOSH equipment. There is no need to plumb in air. This makes the machine substantially more mobile so that as production demands change, you can move your machine to where it is most needed. For instance, the addition of a TOSH machine to a clean room environment is a snap.

Preventative maintenance on TOSH equipment is nearly eliminated. Without cylinders and their associated issues TOSH equipment requires very little care. There is no worry about filters, water or oil in the lines, seal failures, gummed up valve banks, etc.

TOSH machines are quiet. Compressed air is a substantial contributor to the overall noise pollution of your shop floor. Quiet electric drives keep the dB rating low.

TOSH machines are consistent in terms of speed and force. Once you've programmed a TOSH machine, the cycle remains the same until you change it. If you've ever set up a job on a pneumatic pad printer you'll know that changing the speed of the machine often changes the distance and force of the machine. Cylinders take time to fill and settle. Variations in compressed air line pressure and volume will effect print cycle speed and print quality. With an electric drive you are guaranteed smooth consistent application of force at extreme production cadences.

It's very unlikely you are going to run out of electricity in modern day America, running out of compressed air at the end of a drop line 100 feet away from your compressor is another matter all-together.

Linear Guide-ways

In order to take full advantage of the robust construction of our printer bodies, as well as the power and speed of our all electric stepper motors, TOSH machines only use the best linear bearings for motion control.

A linear guide-way consists of a hardened steel rail and a saddle with re-circulating bearings. Most of you know of these products by various brand names such as THK or Thompson. Bear with me as I go into a little more detail as to why we use them and why linear guide-ways provide superior control and performance.

Linear guide-ways can achieve higher precision linear motion when compared with a traditional slide or shaft. Compared with these older technologies the coefficient of friction for a linear guide-way is 1/50th. Because of the way the saddle is captured and loaded on the rail, linear guide-ways can take loads in both the vertical and horizontal directions. This greatly enhances moving accuracy as well as stability when under load.

High Positional Accuracy

When a load is driven on a linear motion guide-way, the frictional contact between the load and the bed is rolling contact rather than a sliding one. The coefficient of friction is 1/50th of that of a traditional contact and the difference between dynamic and static friction is very small. Therefore, there should be minimal slippage while the load is moving.

Long Life with High Motion Accuracy

With a traditional slide inadequate lubrication causes wear between the contact surfaces which become increasingly inaccurate. In contrast, rolling contact has little wear; therefore, machines can achieve a long life with a highly accurate motion.

High Speed Motion with Low Driving Force

Because there is little friction, only a small driving force is needed to move a load. This allows us to size motors based on the force needed for the print job, not for overcoming friction.

What all of this means in terms of a TOSH pad printer is that torque, vibration and whip are minimized or eliminated. This improves print quality and allows the machine to run at higher production cadences. The machine is going to go exactly where you program it to go at the speed you want it to travel. It can reverse direction on a dime and accelerate and decelerate without taxing the motor or increasing vibration.

It also means that your print tolerances typically run better than +/- 0.01MM per color. Accuracy over time does not degrade either as quickly as tradition methods of motion, or to such a degree.

Maintenance on a linear guide-way consists of pumping clean oil through a standard nipple about once a year and cleaning the rails with solvent to remove dust and debris that have accumulated over that time.

All TOSH machinery is stepper motor driven.

TOSH was the first company in the industry to employ stepper motors on its standard equipment. The first all electric TOSH machine was introduced in 1984. This means that TOSH has a 25+ year track record of installing, programming and servicing all electric pad printing equipment. For other companies motor driven machinery is a risky change of direction, for TOSH it is an engineering tradition dating back to the inception of the company.

Properly programmed, stepper motors provide precise control over speed, stroke and force. Once a TOSH machine is programmed to go a certain distance, at a certain speed it will do this until you change the program. This is clearly untrue of pneumatic systems which are subject to variations in air volume and pressure.

(A detailed description of our controls package is discussed in the Electronic Advantages section.)

Stepper motors are incredibly reliable and require no specific maintenance. In more than a decade of installing TOSH equipment in the USA, we have replaced a total of five motors. Two of these replacements were due directly to lightning strikes on the buildings in which the machines were housed. When compared with pneumatic components stepper motors are substantially more reliable. There are no wear components in stepper motors, no seals, no risk of contamination with dirty air.

Stepper motors are simple and inexpensive. Think of the process as a dial divided into 100 steps. The controller tells the stepper motor to go clockwise or counter clockwise a certain number of steps. It could be 1 or 10,000. The motor moves the described number of steps and stops until it receives further instructions from the controller. This is all done with electrical impulse. There are no valves to adjust and no mechanical stops to fiddle with. Every aspect of the machine becomes simplified because every single control is at the operator's fingertips.

Stepper vs. Servo Motors

We frequently get the question of why we use stepper motors instead of servo motors. Since we're on the cutting edge of pad printing, why aren't we using what is touted as the latest and greatest technology? While we accept the fact that servo motors are a great technology for motion control in some applications, we do not feel they are the best approach for pad printing equipment for a number of reasons.

Stepper motors and servo motors are very similar. They are both electric motors with drive shafts that rotate at programmable RPM and produce a certain amount of torque. The main difference is in the open-loop controls of the stepper motor versus closed-loop controls of servo motor. On the face of it, the fact that servo-motors have an encoder constantly providing feedback to the controller about location seems like a good thing. However, in terms of pad printing this provides no advantage.

The feedback loop of a servo motor serves to correct for positioning errors as the motion is occurring. For instance, if we told the printer to stroke 50mm in print position and it encountered an issue the servo controller would continue to push the motor until one of three or four things happened. One, it reach the 50MM position because the obstacle was removed. Two, a programmed time out occurred. Three, the motor over currented and the servo controller told it to idle, or brought the machine home. Four, in theory, the motor could continue to beat its head against the wall until it burned out.

With a stepper, the motor runs through the programmed coordinates that are provided by the controller. If the motor encounters an obstacle that it cannot overcome, say over compressing the pad on the part, it will slip. Our controller tells the pad to retreat to home position and then continue. No damage occurs to the motor or the electronics.

In a real life pad printing situation the only common blockage of movement that would cause a loss of steps or take advantage of the closed-loop feed back of a servo encoder is when the pad is being over compressed on the plate or on the part. It is precisely at these times that you want the machine to "slip", not continue on trying to push past the over compression point.

Why?

The machines are sized to produce a certain amount of force. For argument’s sake let’s say 250 kilos. The entire structure of the machine is built to work comfortably within that zone. Let’s say that by mistake the operator accidentally put in a pad that was 2x as hard as the one typically used for the job. In order to compress this pad the same distance it takes 400 kilos of force instead of 200 kilos. Would it be wise to continue pushing the motor and the structure of the machine? Of course not, and any well written program for a servo motor would make sure that it didn't happen. So what then is the advantage of having the servo motor with an encoder when the stepper motor will respond in precisely the same way?

A common objection is that steppers could lose steps during the process of counting. However, in reality with a properly sized system, it is very unlikely that the motor will lose steps. With our systems, the controller keeps track of home position and makes adjustments if and when they are necessary. This is done with two simple proximity sensors, rather than an encoder.

Another common point is that servo motors can work at higher speeds. This is true and may be important in some processes, but not with pad printing. TOSH already manufactures the fastest pad printing machinery in the world. With most of our equipment and in comparison to most of our competitors the factor is at least 2:1. In many cases it is as high as 4:1. Our speeds bump up against the limit of the pad printing process itself, let alone practical handling of parts by an operator. The excellent "low speed" torque of a stepper motor makes it ideal for pad printing. Speed is relative. Do you need a 747? Or will a Ferrari do the trick when you're competing against a golf cart?

Combine all the technical reasons above with the fact that stepper motors substantially less expensive and it becomes clear why steppers are the obvious motors of choice for TOSH pad printing machinery.

True "U-Shaped" Motion

The motion of a traditional pad printer is driven by two cylinders. The horizontal cylinder moves the pad carriage and the cups front to back and the vertical cylinder moves the pads up and down. This motion has been described as "U" shaped. In fact, this is not the case because there is no curve in the motion. The cylinder slams down onto the plate, up to home position, then forward to print position and down onto the part. It would be more correct to call it a "box" shaped motion. This motion, by its shape, directs all the momentum of the machine into very jarring stop points and thus increases vibration. This effect is so well known that machines are set to slower speeds to allow the pads to settle before pick up and printing, otherwise the vibration of the stop points will transfer into the image and result in blurriness and distortion.

TOSH has solved the problem in a different way. Rather than slow the process down to work with the limitations of poor design, TOSH has developed a truly "U" shaped motion.

TOSH’s stepper motor drive moves a main cam. This is done either via a double belt/ chain drive, or via a direct drive gearbox depending on the machine model. This main cam moves the pads both vertically and horizontally simultaneously through the doctoring motion. This means that the momentum of the machine is mitigated and there is no stop point to create the vibration in the first place. The machine itself moves in a smooth, easy motion. A TOSH machine can run 30-50% faster than a competitive machine and appear to be running more slowly because there are not traumatic stops and starts. This not only improves print quality and total output, it also improves machine reliability. Think about your knees when you’re out for a run. While our competitors are running barefoot on concrete, TOSH is sliding along smoothly on an elliptical trainer.

Suspended Cliché Support

Look closely at the brochure for your TOSH machine and compare it to our competitor’s. You may notice something that doesn’t seem so important at first. The knee on competitive equipment starts at the front of the cliché. TOSH cliché supports are suspended and open under the cliché. What does this mean for you?

It simply means more room: room for your part, room for your fixture, room for your conveyors. If you’re printing a small image in the middle of a big part, on competitive equipment you’d need a big machine to gain the reach necessary. On TOSH equipment because even our smallest machines are wide open under the cliché support, you can reach into the middle of parts that would be impossible otherwise.

Flexible Cliché Support/Cup Support

On TOSH equipment you have a blank slate to set up your ink cups and pads where you want them. A TOSH machine isn't simply a 4 color 90MM machine on a fixed pitch. You can move your plates and cups around on the cliché platform where you need them and you can mix and match cup and cliché sizes as needed.

Eco/Utility Friendly

It's a simple formula: All Electric = Green

We mean this not only in terms of the environment, but also your wallet.

Compressed air is one of the largest secret sources of waste. Its generation, use and storage is incredibly inefficient on every level. It starts with the fact that it requires the user to take a perfectly functional power source, electricity, and convert it into another form. If you've stood near a compressor at a factory, you know how much energy is wasted in this equation. That heat you're feeling didn't generate itself. It is pure unadulterated waste. From there you need to "condition" this new power with a chiller so that it doesn't destroy your machinery downstream with moisture. A chiller is exactly what it sounds like, a giant air conditioner for your compressed air. How much does that cost to run day in and day out?

Once it leaves the tank, compressed air fills your factory lines and, well… leaks out of every single joint and connector. 30% of compressed air generated in a typical factory is lost due to leaks small and large. Think about that. After the inefficiency of converting electricity to compressed air, you'll lose another 1/3 before it even gets to a machine!

Our smallest machine, the TOSH Micro 90 will save you approximately $500.00 per shift per year in operating costs. This number is purely related to the electrical usage. Maintenance of the compressor and chiller is not factored in. As machine sizes increase, savings do as well in proportion to the amount of force generated by the machine and the number of cycles per hour. We'll be happy to work up an energy audit for you on any system we provide.

Proprietary Controls and Software

If the stepper motor is the heart of a TOSH machine the controller is obviously the brain.

TOSH uses proprietary controls and software to run all of its machinery and conveying accessories. This is truly out of necessity. TOSH was (and still is) building machinery unlike any of its competitors. Off the shelf programmable logic controllers are too expensive, cumbersome and slow for TOSH modular equipment. TOSH designs its controls from the ground up for the pad printing process.

Twenty-five years of continuous development, field testing and improvements have led to the most advanced controls package in the pad printing world with a sustainable and stable upgrade path for every machine built.

Built in Upgrade Path

One of the key advantages of TOSH's obsession with controls is that there is a viable upgrade path for every machine in the field within the limits of its size. In modern manufacturing, production requirements change constantly. Today a table top machine with a 2 position indexer might suit your needs exactly. In a month, you could need a high speed rotary table. Rather than having to go to a third party vendor for conveying accessories, TOSH already has a plan in place for you. Since TOSH builds all of its own conveying accessories it is only a question of a few hours of assembly to add a rotary table and reprogram the software. Every TOSH machine comes with built in controls for a range of conveyors and parts position devices.

Complete Cycle Control

Every TOSH machine allows for complete control of the cycle through the keyboard of the machine. This is unheard of on competitive equipment and is a function of TOSH’s stepper motor drive and proprietary software. Included on every machine are:

Independent Speed Control in Every Axis of Motion

There are 6 motions in every pad printing cycle. Doctoring forward, doctoring backward, pad down over plate, pad up over plate, pad down over part and pad up over part. If you’ve pad printed, you know how critical these speed are to a quality print. This being the case, why do many manufacturers ignore these controls, or put them out of reach of the operator? TOSH puts them at your finger tips.

Independent Delays/Timers in Every Axis of Motion

Why slow down the overall cycle, when all you need is a 1/10 second delay to allow the ink to tack off before printing? What if you want to pause on the part for ¼ second to allow the pad to conform to a difficult texture? With TOSH equipment you have the opportunity to program delays before ink pick up, on the cliché, before print and on the part. Once you’ve used these features to fine tune your process you will never be able to use a machine without them again. (Which, unfortunately for our competitors, is every other machine on the market today.)

Independent Stroke Adjustment in 1MM Increments over the Cliché and Part

Have you been using limit switches and knobs to adjust your strokes? Does your machine have no adjustment at all? Why not just tell it where you want it to go? With a TOSH machine, if you need 1mm more or less compression, you push a button and you’re there. Exactly what you need, when you need it.

Training Mode

When setting up your machine for a new application, TOSH software gives you the flexibility to walk the machine through the cycle. By holding a button you can slowly jog the machine into position, hit enter, and the machine learns the stroke. Training mode allows you to quickly set up a new program (which can be stored to memory) in seconds.

Stepping Mode

All motions of the machine can be run independently when the machine is put into stepping mode. Isolate doctoring, pad stroke, or indexing so you can see exactly what your machine is doing. This can be run at full speed, or in incremental steps.

7 Languages

All TOSH machines are meant to travel. They can be programmed in English, Italian, Spanish, German, Portuguese, French and Swedish. You can toggle between these languages as needed.

Multi-Program Memory

Programs can be stored in the memory of the machine for immediate recall.

Easy to Automate

TOSH machines are easy to automate. If you are using TOSH conveyors, you can mount the accessory and add the necessary driver card and call up the program that is pre-loaded into the controls package. If you wish to integrate TOSH equipment with your line, there are all the necessary inputs and outputs present, built in for your convenience.

Counters

TOSH machines have a number of useful counter features. There is an overall life cycle counter for the machine itself. There is also a batch counter to help you keep track of each job. The machine will also provide you with a live "cycles per hour" counter so you can see how much production you should expect from a certain set up over the course of a shift.

Conclusion

I've heard the phrase "all pad printers are the same" week in and week out for more than a decade. One thing I can promise you is that this is not true. With all of these features TOSH makes many impossible print jobs possible, marginal print jobs standard and easy jobs serious money makers. I believe it is critical when you sit down to make a final decision on your pad printing equipment purchase that you take into account not just the "bottom line" price of the equipment but the real bottom line production cost for your parts. If you're committed to manufacturing in the USA, you know that a zealous commitment to efficiency, speed and precision are your only chance at fending off the competition. It is a fact that you have to pay your workers ten times the rate of any overseas manufacturer. It is my suggestion that you level the playing field by providing them with the best tools for the job. Increase your real output, decrease your set up times and watch your margins improve. Isn't this what real productivity is all about?

8. Options and Accessories

There are a lot of options and accessories to go with pad printing machines. This chapter will review popular accessories by categories, including accessories for printing multiple colors, conveying parts, pre- and post-treatment, ink management, and more.

Accessories for Printing Multiple Colors

Most manufacturers offer machines in one through four, six or perhaps as many as ten color configurations. (Ten is the most I have ever seen). To print multiple colors you have to have some type of accessory.

Multiple color open systems can have multiple clichés, or one cliché in a split inkwell. Independently adjustable clichés are, in the author's opinion, desirable over having all of the colors on a single cliché. The benefit of independent clichés is simply the ability to absorb potential image to image and / or image to part location problems more easily.

Split Ink Cups

Split Ink Cup. Photo:Tampoprint.com

A few manufacturers offer small (60 mm) multiple color ink cups (commonly referred to as "split ink cups") that allow you to print two or three colors. The limitation is that the colors are going to have to be side by side, unless your machine can pick up once, then stroke the print two or three times. In that instance, you can shuttle the part to print colors on top of one another. The other limitation is that these cups are difficult to manufacture, and thus expensive.

Pad Shuttles

Three color Pad Shuttle. Photo: www.padprinters.com

Pad shuttles can be a less expensive alternative to the purchase of a larger machine in some applications. Using a split pad a pad shuttle can, in some cases, print an image that would otherwise exceed the cliché or ink cup's maximum image area. For example, let's say you have two images of the same color that must print with their respective centerlines being 45 millimeters apart. When etched separated by this dimension the two images don't fit within your machines maximum image area. If these two images fit when separated by for example, 30 millimeters, then you could etch them that way, pick them up with two pads butted together, and shuttle the two pads apart to achieve the desired 45 millimeter separation prior to image transfer.

Pad shuttles can also be used to print two images on two different sides of the same part when both images, etched side by side, are picked up at the same time by two separate pads. After image pick up the pads move along the X-axis to position the first print. After the first print the nest rotates while the pad shuttles into position for the second print. In order for this to work your machine needs to be able to pick up once and print twice, and you must have both a pad shuttle and a rotating nesting fixture. You can also print two colors this way if you have two-color ink well on a one color machine. Pad shuttles are an interesting option. Most pad shuttles pick up two or three images simultaneously, print one color, then shuttle to print the second and / or third color either on the same location as the first, or somewhere else on the part, depending upon the capability of the machine.

Once you get to the point where you have to print more than three colors your only option is to incorporate some type of part conveying accessory. Part conveying accessories are discussed in the next chapter.

Part Conveying Accessories

There are several types of equipment that are considered to be part conveying accessories. The three most important characteristics for part conveying accessories are speed of travel, accuracy of travel (and how they attain it) and overall durability. A slow conveyor is wasting your money. An inaccurate conveyor will make multi-color prints impossible. A temperamental conveyor will not withstand the enormous number of print jobs you will be processing when you become the fastest printer in your area.

Additionally, it makes sense to look at other features the supplier might offer. Is the system upgradeable? Can you easily replace your two-position linear indexer with a rotary table when demand increases? Are the units truly integrated, or are they using stock components from outside manufacturers such as Camco? Finally, how programmable are the units? Can you adjust speeds, distance of travel or the number of stations? Based on your specific needs all these questions will help you decide what system is best for you.

Linear Indexers

Linear Indexer. Photo www.padprinters.com

There are basically four kinds of Linear Indexers: pneumatic, electronic, stepper motor driven and manual. Pneumatic linear indexers are the least expensive. Pneumatic linear indexers can have multiple positions by means of either multiple cylinders, or a single, more expensive cylinder with magnetic brakes. One has to be very careful to avoid any fluctuation to air pressure when working with parts of a critical nature on pneumatic indexers. They aren't as accurate as electronic or stepper motor driven indexers, and when air problems exist they can be rendered completely unreliable.

Electronic linear indexers have programmable, servo-driven motors. These shuttles are more expensive than their pneumatic or stepper motor driven counterparts, and somewhat hard to find.

Stepper motor driven shuttles can be programmed to travel a desired number of steps between prints. Stepper motor and electronic shuttles will typically last longer and are more reliable than pneumatic indexers, and are less expensive than true "servo" driven electronic indexers.

A linear indexer is the most basic of all part conveying accessories. It can be a simple two position pneumatic unit with few inches of travel, or it can be stepper motor driven with up to two meters of travel. The concept is simple. The operator loads the part in home position and cycles the machine. It moves from one position to the next until all the colors have been transferred onto the part. Then it returns to home position where the operator can remove it.

This is the slowest method of moving the part available because the actions occur is series rather than parallel, but it will work nicely for relatively short run multi-color jobs. It only requires one fixture, which translates into quicker change-over between jobs.

Linear Indexers are well suited for applications requiring multiple axis part conveying. At Innovative we stack programmable linear indexers in perpendicular axes, allowing us to convey parts in multiple axes as in the multiple location example discussed earlier.

Manual "indexers" are really just two position slides that can be used for low volume jobs where the registration of colors is not critical.

Rotary Tables

Rotary Table

Photo: www.padprinters.com

Rotary tables can also be electronic, stepper motor driven or pneumatic. Accuracy and price are determining factors. Electronic and stepper motor driven rotary tables are more expensive than pneumatic ones, but they can move more weight (a consideration when using multiple nesting fixtures machined from aluminum or other materials) and they can move it much more accurately than pneumatics. Rotary tables can be of just about any reasonable diameter, allowing anywhere from two to a couple dozen or more fixtures to be attached.

Some manufacturers have modular rotary systems with up to four independently adjustable machine mounting stations. Depending upon the application, one, two, three or all four machines can be used simultaneously, turned off individually, and even rotated 180 degrees on their mounts to operate alone, allowing more than one job to run at the same time.

One huge plus for stepper motor driven rotary dials is their ability to be reprogrammed for different applications. In the case of TOSH rotary tables you can choose the number of times you wish to index. For lower volume jobs or jobs printing on larger parts you can choose fewer indexes. For higher volume jobs or jobs printing on smaller parts you can fit more on the dial, choose more indexes, and print faster. This programmability also allows you to be able to more easily integrate other pre- and post- printing accessories like corona or flame pre-treatment and in-line hot air drying.

Rotary tables are a fast, efficient way to automate the pad printing process. They can be pneumatic, cam driven or stepper motor driven. Because they come in so many sizes it is possible to use them for the majority of small to medium sized parts.

Typically the rotary table will sit on the knee of a free standing pad printer. The operator will load at 6:00 and the machine will print at 12:00. Choosing the right sized dial will allow you to integrate pre-treat and post treatment before and after printing.

When choosing a rotary table it is important to remember that larger dials have two draw backs. The first is accuracy. The farther you are from the center point, the less accurate the index tends to be. A tenth of an arc second variation in the index eventually adds up to a noticeable inaccuracy as the dial gets bigger. While this can be solved by shot pinning the nests on station, doing so only serves to slow the process down.

The second issue with rotary tables is fixtures or tooling. You'll want to limit the number of stops to the minimum necessary to complete the job and maintain ease of use. There is no sense using a 24 position rotary table for a simple job that on requires a load, print and eject station. Six stations should be adequate and will cut your tooling costs dramatically. However, you may be tempted to go even farther and only use three or four stations. Remember that the higher the number of stations, the shorter the index and thus the longer the dwell time on station. Longer dwell times make it much easier for your operators to handle high production cadences.

Ideally, you should purchase a rotary table that gives you a choice. Stepper, or servo motor driven indexers can be programmed to have different numbers of stops. This week you may be printing a four-color cell phone bezel with 18 fixtures, but next week, you may have a short run part that doesn't justify 18 fixtures. If the rotary table is programmable, you can remove the phone bezel fixtures, replace them with the fixtures for the other part, punch a few buttons, and away you go.

Even a two position rotary dial will increase your throughput by making loading and printing a parallel process, thus allowing the operator to keep a higher production cadence than if he or she were manually loading and unloading a single fixture.

Flat Oval Conveyors

Flat Oval Conveyor / "Racetrack Conveyer"

Photo: www.padprinters.com

"Flat Oval" or "racetrack" conveyors are standard equipment on many multiple color machines. Pneumatically or stepper motor driven, racetracks can have several nests or fixtures.

Oval or "racetrack" conveyors are strange beasts. They are not widely used outside of pad printing and are becoming less common. Typically they are pneumatic or motor driven with shot pin alignment mechanisms on the critical print stations. The fixtures move clock wise in an oval. Parts are loaded by the operator on one of the fixtures closest to them and are conveyed under the print head. Conceptually they bridge the gap between a rotary table and a linear indexer, which will be described below.

The main benefit of an oval conveyor is that they present the parts in a straight line to the print head. Linear alignment of the plates may be faster than on a rotary table because multi-color printing on a rotary table requires that the artwork be positioned so as to correct for the angle of the fixture in relation to the print head. Drawbacks of oval conveyors typically include speed, tooling costs and difficulty integrating with systems such as parts feeders.

Linear Conveyors

Linear Conveyor / Under-Over

Photo: www.padprinters.com

Linear conveyors (commonly called “under-over conveyors) are usually chain driven or precision-link mechanically driven. In most cases parts simply fall off the nests into a container at the end of the line, or are transferred to separate conveyor for subsequent operations. A few manufacturers use the bottom of under-over conveyors for secondary operations.

TOSH offers a unique linear conveyor that brings the parts back around at a 30 degree up angle instead of inverting them after printing (pictured above). This allows you to perform some operations after printing, and it makes automatic loading easier.

Linear conveyors should not be confused with linear indexers. With a linear conveyor a large number of fixtures ride in a continuous loop, like the pads on a tank track. Their rail-guided fixtures are typically shot pinned on print locations. Most linear indexers used in pad printing are chain driven.

Linear conveyors are not typically considered ideal for shops doing large numbers of custom jobs. They are meant to be dedicated to a particular product, or family of products. The linear construction makes them ideal for integrating feeder bowls, pick and place mechanisms as well as other operations, such as ultrasonic welding, leak testing or inspection. Usually they are suggested when a manufacturer has a large run that will go on for more than one year. Otherwise, it would be difficult to justify the expense of the unit itself plus the additional cost of tooling and guarding.

Walking Beams

Walking beams are a mechanical means of moving parts from one print station to another. Walking beams are limited in that they usually require that the part be picked up, moved over, and located against a stop of some sort for each printing operation. In most multiple color operations it is not recommended that the part be moved in this fashion.

Adding a part conveying accessory usually has the benefit of allowing you to add pre- or post-treatment equipment to the system. Pre- and Post-Treatment are discussed in the next chapter.

Pre- and Post- Treatment Accessories

Many plastics, such as polyethylene and polypropylene, have chemically inert and nonporous surfaces with low surface tensions causing them to be non-receptive to bonding with printing inks, coatings, and adhesives. Although results are invisible to the naked eye, surface treating modifies surfaces to improve adhesion.

I commonly use the following analogy when I am explaining the concept of “high” and “low” surface energy to people: Have you ever waxed your car? Do you know how, when the car needs wax, and you spray it with water while washing it, the water “sheets out” smooth? That is high surface energy. The surface is “wetting out”. Once you’ve waxed the car, water “beads up” and runs off (does not adhere). That is an example of low surface energy.

Surface energy is measured in Dyne / cm^2. In pad printing we usually use Dyne test pens, which contain dyed fluids that either wet-out, or bead up, depending on the Dyne level of the material tested. For pad printing, we want a minimum Dyne level of 38 Dyne / cm^2. 42 is better, and anything above that is preferable.

To test a surface, you simply swipe the various pens across it and watch to see if the line stays solid (indicating that the fluid wet-out as desired), or if it beads up (indicating that the surface is below the level of the indicator fluid). For example, in the following photo (courtesy of www.dynetechnology.co.uk), you can see that the surface being tested is at or above the minimum 38 Dyne / cm^2, but below 44 Dyne / cm^2.

Photo: dynetechnology.co.uk

Once you've determined whether pre-treatment is required, you need to figure out what type of pre-treatment method best suits your applications. There are several methods for pre-treatment, including several variations of corona, (sometimes referred to as air plasma), batch plasma, flame plasma, chemical plasma, Pyrosil and liquid primer.

Corona / Air Plasma

Corona or air plasma discharge equipment consists of a high-frequency power generator, a high-voltage transformer, an electrode, and a ground. It is safe, economical, and delivers high line speed throughput. Corona treatment is also suitable for the treatment of injection and blow molded parts, and is capable of treating multiple surfaces and difficult part geometries with a single pass. Polyethylene, polypropylene, nylon, vinyl, PVC, PET, metalized surfaces, foils, paper, and paperboard stocks are commonly treated by this method.

In simple terms, corona is "kind of" like generating artificial lightning, and either placing the part between the positive (electrode) and the ground (commonly used for flat stuff, like paper or web fed plastic media), or by using forced air to blow the lightning onto the surface of the part. Blowing is more popular in pad printing, since most of the stuff we print is three-dimensional.

The "lightning" polarizes the substrate by placing a positive charge on the end of the substrate molecules, thereby allowing it to attract the negatively charged pad printing ink.

The effects of corona pre-treatment diminish over time, so in pad printing we normally prefer to integrate corona pre-treatment into the pad printing system. To do this we simply mount the pre-treatment head (or heads, if the treatment area is too large for a single head), and convey the part beneath the head(s). Distance from the treatment head to the surface is critical (too far away and you don't get sufficient treatment, to close and you can "scorch" the substrate), as is time, (Too little time = not enough treatment. Too much time = scorching, potentially).

As I mentioned, there are several variations of the corona method. Additional methods include atmospheric plasma, flame plasma and chemical plasma.

In atmospheric plasma, the overall density of the plasma field is much higher, enhancing the rate and degree with which the substrate is polarized. This results in stronger material bonding. Atmospheric plasma is often used when it is important that only one side of the substrate is treated.

For example, a typical application for corona would be an under-hood fuse box cover for an automobile. Molded from polypropylene, you might need to print a schematic indicating what fuse if for what on the inside, and the words “Fuse Box” on the outside.

In that case we would use a custom shaped electrode that could be actuated (using a cylinder or perhaps a robot) down into the inside of the fuse box until the optimal clearance between the electrode and the substrate is obtained. On the back side, a gap of equal distance would be maintained between the outside of the fuse box, and the nesting fixture, which would serve as the ground.

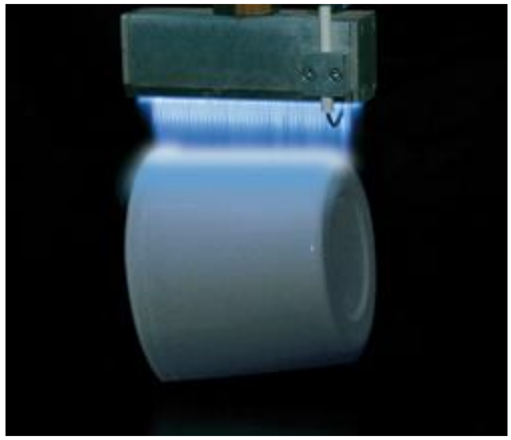
One problem that can potentially occur with corona / air plasma is “lightning strikes”, which are visible differences in the gloss level of the substrate. This is usually only visible on darker materials, and usually diminishes significantly or disappears completely over time.

Batch Plasma

Batch plasma involves placing parts in an enclosed environment, then filling the entire enclosure with corona, effectively pre-treating all surfaces. This method can be useful over a broad range of part dimensions and geometries. Batch plasma is widely used in laboratory settings, and where the parts being pre-treated are smaller.

Flame / Flame Plasma

Flame, or flame plasma, generates more heat, but lasts longer than corona. However, it has many benefits over corona in that its effects last longer, is better than corona for large, three-dimensional surfaces, is faster (doesn’t require ‘dwell’ time over the parts), and, when set up correctly, won’t damage the parts mechanically or aesthetically.



Flame Pre-treatment

Photo: Enercon Industries

Chemical plasma

Chemical plasma is based on the combination of air plasma and flame plasma. Much like air plasma, chemical plasma fields are generated from electrically charged air. But, instead of air, chemical plasma relies on a mixture of other gases depositing various chemical groups onto the treated surface.

Pyrosil

Pyrosil is similar to flame, however it differs in that the gas contains chemicals that, when exposed to the flame, oxide and precipitate onto the substrate's surface, essentially forming a thin layer of silicone dioxide. The resulting silicone dioxide layer has a very high surface energy. Pyrosil is used to pre-treat glass and metallic materials. With some metallic materials, Pyrosil also reduces oxidation.

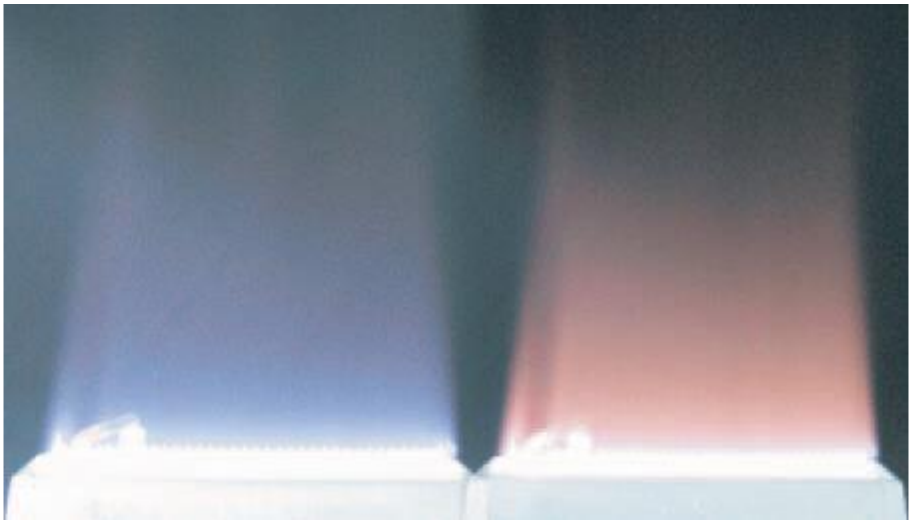


Photo: Pyrosil

In the photo above left you see a standard, blue flame ribbon. At right is a Pyrosil ribbon, which is easily identified by its reddish color.

Liquid Primers

Liquid primers are a last resort to any of the pre-treatment methods mentioned previously. Liquid primers are essentially very aggressive solvents that you either dip parts into or wipe parts with. They are so aggressive to plastics that in most cases you need special gloves to project personnel, as well as adequate ventilation or a mask for the operator, plus safety goggles. Additionally, women who are nursing or pregnant should avoid handling liquid primers.

Static Control Equipment

Sometimes static is a problem. Packaging materials, plastics, the friction of the machine, or even low humidity can generate static. When necessary static control equipment like de-ionizing air nozzles and air knives can be added to the pad printer or feed systems. They come in almost any size, from tiny blowers with pin-point apertures to wide-web static elimination bars.

Hand held static eliminating blower. Static elimination bars / air knives,

Static elimination blower.

Photo: Google

Hot-air Guns

Hot air guns are frequently integrated with racetrack conveyors and rotary tables. Even though most pad printing inks dry to the touch within a few minutes, most people prefer to have the additional drying equipment, especially if they are using two component ink or multiple color printing with a lot of coverage, or at high speeds.

Some hot air guns, such as Leister (pictured below), maintain a constant core temperature at all times. These can be set-up with a simple timer and clean, dry, compressed shop air to blow through the core onto the part.

Pad Print Dryer

Pad print dryers come in all shapes, sizes and types. A typical pad print dryer such as one pictured below is electric. The one pictures is six feet in overall length, with a 24-30" oven, a 13" wide conveyor belt, temperature and belt speed controls, and little chute off the exit end of the conveyor.

Photo: Ranar

The dryer shown here is pretty typical of what most people use. Of course, you can with a smaller, table-top dryer without legs, and you can go with much larger, wider dryers with multiple zones for heating and cooling.

Infrared Drying

You might also consider infrared (I.R.) drying. IR heat transfer occurs when a temperature difference exists between two bodies (i.e. the lamp, and the substrate/ink film). Unlike convection (dryer) or conduction (hot air gun) heat transfer, IR does not require physical contact between the source (lamp) and the target for heat to flow. (Conversely, with convection, the heat source heats the air, which in turn heats the substrate/ink film).

Convection/conduction is based upon the first power relationship of the source temperature. For example, if the element heats the air to 275 Fahrenheit, the air, in turn, heats the substrate/ink film to 275 Fahrenheit. IR is basically "invisible" to gases (like air), so it doesn't heat the atmosphere inside the curing unit. If the system is focused, the lamp(s) will heat the reflector, which is usually water-cooled.

Infrared heat transfer is proportional to the fourth power. If the IR has a source temperature twice that of a convection heat element, the radiant heat transfer is 16 times higher with IR than with convection. Obviously, the result is a significantly lower curing time. Cooling requirements for the product are also reduced, since IR doesn't need to get the substrate hot in order to cure; only the ink film.

Other benefits of IR compared to convection are "instant on-off", whereas convection ovens need to be pre-heated. Conduction (hot guns), like the Leister hot air dryers mentioned previously maintain a constant internal element temperature and use forced air to transfer that heat to the substrate/ink film. Essentially, conduction in the case of the Leister units offers "instant on-off" as well, although the heat transfer is still based on the first power, resulting in a longer dwell-being necessary than with IR.

IR does have some limitations, particularly with regard to the effective removal of VOC's from the ink film. If you have a specification related to out-gassing (i.e. automotive), IR is probably not going to be the way to go. IR also yields a less consistent cure than conduction or convection, and is more expensive to purchase (by a factor of 2X on average) and maintain (lamps have an average life of 1500 to 5000 hours and are expensive to replace). Power usage for IR, versus an efficient convection or conduction system, is basically a wash.

Finally, ink manufacturers typically don't provide IR curing parameters for their products, so it becomes the responsibility of the ink / IR user to determine processing parameters.

In conclusion, the main advantage of using IR is a faster curing cycle and a reduced footprint. The main disadvantages are a narrow processing window, entrapment of VOC's, a higher capital investment, and higher maintenance costs.

U.V. Curing

Everyone wants to use U.V. inks because the idea is that they instantly cure when exposed to U.V. radiation. I will address that in the chapter about pad printing inks.

U.V. drying is great, if you can use it in your application. Like pad print dryers, U.V. curing equipment comes in lots of sizes and shapes.

For smaller format products, small, table –top systems such as the one from Fusion U.V. *(now Heraeus Noblelight Fusion UV)* pictured on the next page work very well. Of course, you can also get conveyor U.V. curing units in much larger sizes.

Photo: Fusion UV

When it is required that the lamp be integrated with an existing production or conveyor line, you would need the lamp and power supply separated, as shown below.

Photo: Fusion UV

U.V. + I.R.

In pad printing, U.V. inks need to have solvents added. Normally, U.V. inks do not contain any solvent. For this reason, U.V. curing units alone may not cure pad printing inks. Sometimes it is necessary to integrated I.R. with U.V. to first evaporate the solvent from the printed ink film before exposing it to U.V.

Pad Pre-Drying

In many applications, single and multiple color alike, it is necessary to increase the amount of airflow over the surface of the part and / or the pad in between prints to speed drying and increase adhesion of subsequent colors.

Pad pre-drying devices can be simple, single head units having their regulator mounted to a magnet, with flexible plastic tubing that allows you to stick the base of the blower to the side of your machine and bend the tubing around to direct the air exactly where you want it to go.

For more complex application, you may need to have two separate blowers at each color station, directing one at the pad, and one at the part, as shown below. Here you can see a seven color application, with each color station having multiple orange tipped pad pre-drying blowers mounted to flexible, blue tubing, which are mounted to a single, larger manifold on the knee of the machine.

Photo by John Kaverman.

Automatic Pad Cleaner

Also known as "tape-off" or “taper”, automatic pad cleaners can remove debris from the pad very quickly. These systems can be add-ons to existing machines, or built-ins on some newer machines. In most cases the frequency of tape-off (cleaning) is programmable. Usually the tape-off occurs after image transfer. After the pad prints and returns to the "up" position a slide mechanism positions a "tray" under the pad. The surface of the tray is covered by an adhesive tape (similar to packing tape, but with less adhesive and a stronger carrier). The “tape” is on a reel-to-reel, and is actuated either via pneumatics or a small motor. The pitch, or distance the tape indexes after each cleaning cycle, is usually adjustable.

Ink Pumps

Ink pumps are sometimes used on automated open systems. Particularly useful on rotary pad printers, ink pumps automatically control ink viscosity. Usually the ink drains from the lowest point in the ink well into a container where thinner is automatically added and mixed into the ink. The ink is then pumped back up into the ink well or ink cup. Unless you're using the same color of ink all of the time, and running at very high production speeds, ink pumps are not something you really need to consider.

Thinner Metering Systems

Automated closed cup machines can have thinner metering systems added to continuously add thinner to the ink cup. These systems simply drip a pre-determined amount of solvent into the top of the ink cup at regular intervals. Basically, it is like hooking an I.V. pump up to your ink cup.

Some manufacturer's designs do include something to mix the ink automatically as thinner is metered in. While these work nominally better than systems not having mixing, in most cases a thinner metering system is overkill at best, and completely unnecessary, or even a hindrance to print quality at worst.

It is important to remember that thinner metering systems add only thinner. They do not add any ink resin, pigment, or in the case of two component inks, any hardener. Simply adding thinner over and over again to control viscosity, without adding the other components (resin, pigment and hardener), you eventually break the ink down to the point where the components separate from one another. At that point print quality, especially with regard to opacity and resolution, will deteriorate rapidly.

Nesting Fixtures

All too often nesting fixtures are an afterthought in tooling up for a job. In pad printing it is necessary for the part to be properly supported, especially at critical stress points and areas where the forces of pad compression are greatest. The nests also need to be ergonomically correct (worker friendly). When several nests are necessary, as is the case when you're tooling up any multi-station part conveying system, they all need to be precision made. In some applications the type of pad to be used must be taken into consideration when designing the nests.

In the interests of saving time and money it is sometimes tempting to go to the tool maker down the street to have your nests built. That is fine, provided that your toolmaker has experience dealing with pad printing. On several occasions I have seen quality problems result from a lack of pad print process knowledge in the design of nests, especially on automated systems.

Pad printing equipment manufacturers should know how to design and build nesting fixtures correctly. Let them build your nesting fixtures, at least until you become proficient enough to be able to educate the toolmaker down the road.

Of course not all parts are critical enough in nature to warrant having someone build your nests. Some parts require little more than double sided tape or a lump of modeling clay as a nest. A lot of people make their own nests for one-up printing jobs by using automotive body filler. You can find or build a container, mix up the filler, pour it into the container then seat your part in at the angle you want. (Spray the part first with a light lubricant so you can get it out of the filler after it cures.) After about a half an hour the filler is cured hard enough for uneven surfaces, tight corners and rough edges to be sanded away for a reasonable consistent fit.

Safety Enclosures

Operator safety is everyone's concern. Some pad printers don't require any safety equipment while others require complex enclosures or light curtains.

Most automatic machines come with standard safety guards or shields that are effective and don't interfere with the efficient operation of the printer.

Photo: TOSH

The system shown above, manufactured by TOSH of Italy, features a complete enclosure, with aluminum frame, interlocked polycarbonate doors, and a light curtain across the front (load / unload) of the machine. This illustrates an efficient method of guarding a machine, while not adversely affecting its efficiency.

In some manufacturing environments I have seen perfectly good machines rendered almost useless by the addition of poorly designed safety enclosures. Unfortunately there are individuals that will hurt themselves regardless of anything you can do in an attempt prevent it. Common sense can't be taught, but it can be made a requirement.

Common sense can't be taught, but it can be made a requirement.

If you're responsible for purchasing equipment or making safety policy decisions, consult with everyone involved: operators, supervisors, the equipment manufacturer and O.S.H.A. regulations to ensure that your new machine will be both safe and effective.

Other Options and Accessories

In addition to the numerous options and accessories that I've mentioned in this chapter, you can have part hoppers (to hold unprinted parts), elevators, orientation, loading, color and vision inspection, unloading and robotic handling. In most cases those are not items that the pad printing equipment manufacturers make themselves. They are, however, items that competent pad printing equipment companies should know how to integrate.

U.S. companies are starting to "on-shore" and "in-source" pad printing jobs that were previously sent overseas, or farmed out to contract decorators. In order to do this and remain competitive in the global marketplace, U.S. manufacturers are increasingly seeking more automated pad printing solutions.

9. Automated Pad Printing

Here is a familiar scenario: Your company just bought a pad printer and saved a ton of money buying it over the internet, or maybe you bought a ten year old dinosaur at that was on the block at a local molder that just went out of business. Sure it lacks some of the so- called "features" of the more expensive machines. While you realize the equipment has no options for upgrading, you're pretty happy with yourself because you "saved money". Congratulations. You are now officially the technological equal of your recently failed competition.

If I sound like I am wound a little too tight on this topic it is because I spend a good portion of every business day listening to potential customers bemoan the loss of business overseas and about shrinking margins. It doesn't need to be that way. With some planning, rational investment and a little creativity you can compete and win by automating.

Reasons to Automate

The reasons for automating your pad printing process are generally fall into two different categories: *application specific automation* and *efficiency specific automation*. In each case, parts handling equipment such as linear shuttles, rotary tables, oval conveyors or linear indexers are used to convey the parts through a number of processes.

Application Specific Automation

People usually embark on application specific automation as soon as they have to print more than one color, print multiple locations or on multiple axis of the part, pre-treat the part, or post treat the part.

Multiple Color

For example, if you need to print a four-color logo on a ball it would be tedious or impossible to do it in individual steps, and it certainly wouldn't be cost efficient. Instead, it makes sense to put the ball in a fixture and maintain control of it throughout the process. That way the operator only has to load the part once, and registration is maintained. While not particularly fast, even the simplest pneumatic linear shuttle is more efficient than reloading a part by hand.

Multiple Location

Consider how you would pad print a 36" long appliance panel in six colors. Without automation you would need to perform multiple set-ups. With modern programmable printers and integrated part conveying accessories you could complete the same part in a single cycle.

Pretreatment

Other applications that point toward automation are parts that necessitate pretreatment, or post treatment. Polyolefin normally require pre-treatment in order for the printed image to obtain maximum durability. In automation this is normally accomplished using corona or flame pre-treatment.

An operator using a hand held flame treatment unit on a table won't be able to treat the parts consistently throughout the day and risks not only damaging the parts, but injuring themselves as well. Done in-line, pretreatment can be precisely timed and locked away behind safety doors. Your quality will go up and your labor cost per unit will go down.

Post treatment

Post treatment via a hot-air blast is also practical. It allows the operator to immediately handle the part, or for automatic ejection equipment to push the part into a bulk bin or onto a conveyor. In addition, an in-line hot air gun takes up substantially less floor space than a dryer tunnel. If your operators are putting parts on a table next to them to dry, they are touching the parts too many times and eating up your margin.

Efficiency Specific Automation

The other reason to automate your process is speed. Speed is the name of the game, if plastic decorating is going to survive in the United States. Speed reduces the labor cost per part and also helps buy back the initial capital investment more quickly. Flexible, high- speed equipment allows you to print more jobs in a shorter time with fewer people. In today's "just in time" environments, faster throughput can also be used as a selling point to your customer.

You may have heard that the pad printing process is limited by the solvent evaporation dynamic. In essence people have told you that after a certain speed is reached, it is impossible to transfer the ink completely and print quality deteriorates. Have you noticed that this magic number is somewhere close to the maximum speed of the equipment they are selling?

While this limitation is true in theory, at Innovative we have noted that on typical applications the upper end is substantially higher than most people have been led to believe. For instance, we have printed a large four color image on standard equipment combinations at rates in excess of 50 parts per minute. It is common for us to attain 30-40 parts per minute on multi-color applications, even when an operator manually loads and unloads parts.

This type of speed will distance you from your competition up the street and across the globe. How do we achieve it? Part conveying accessories.

The Vicious Cycle of Under-Investment

We don't know how to put this politely. You're going too slowly and you're charging too little. The thing is, I'm not asking you to raise your piece price to your customer, just your hourly rate.

You're probably estimating jobs at anywhere between $25 and $35 per hour. This covers your labor, your overhead and your job related expenses such as pads, ink and clichés. If you can, you also charge a set-up fee each time the job starts and stops. Occasionally you highball a quote and get the job, but it's usually a short run. Customers who buy in large quantities know better, and while they're more difficult to handle, these are the customers you want and need. So you labor on and pay the bills, there is even a small amount left over for profit. There is nothing for reinvestment.

Your labor rate is your first mistake. You should charge no less than $50 an hour, preferably more. Yes, I understand that it is impossible. Yes, I know your competition will eat you alive, but let's put this in perspective. The guy who comes to unclog the toilet charges $80. Your cleaning lady expects at least $25. Your lawyer, let's not talk about your lawyer. Do you think your services are worth any less than any of these people? Neither do I.

Here's the secret and it's not exactly a fit of genius on my part: You must double or triple your production cadences. To do this you must take the plunge into faster equipment with parts handling capability. Otherwise you will continue to lose every job that grows to more than 100,000 pieces per year and as we all know, these jobs are where the money is.

It is my opinion that every job over 10,000 pieces should be automated in some way. It does not have to be complex. Two fixtures on a small rotary dial will increase your output tremendously and will not cost much more than doing it as a single station. After a while tooling up a rotary dial comes naturally. You can pay for your next piece of automation by ensuring that your operators get in the habit of this "new high-speed throughput" and that you maintain your pricing levels.

The most difficult part is getting started. There is no avoiding the fact that this will cost some money up front. If you can pass it on to your customer somehow that would be ideal, but don't bet on it. You will probably have to bite the bullet and look at it as a long- term investment. If you look at the math it really isn't all that painful.

Let's say that you have twelve automotive jobs that average 75,000 pieces each per year. On average you are printing 10 parts per minute. The jobs are 1 color and have a print area of under 50 mm in diameter. With downtime, change-over, etc. that is about 2000 hours' worth of labor. At $25 per hour, that is $50,000 worth of work. Not bad. If your real costs are $20 per hour then your gross profit is $10,000. Twenty percent isn't half bad, but it won't pay for much in the way of future upgrades.

To automate the process, you need to spend an additional $15,000, but you increase your production cadence by an easily attainable factor of 2.5. Total hours drop to 500. Thus gross profitability increases to $40,000. The new profit margin less the capital investment is an astonishing $25,000. Better yet, you have 1500 additional hours left on that shift to run the equipment on other jobs. Plus, you will not need to find additional skilled operators to keep up with demand. Maybe you can even give them a raise. You customer will be thrilled by the faster turn around and if they start making noises you now have plenty of margin to give them a price break.

Maybe this sounds like a fantasy to you, but these figures are a simplified version of a story of a customer who stirred up their courage and took the plunge. The funny part is, they had no idea how successful they would be. Originally, they had planned on buying two more systems to keep up, instead they're running so fast that they've idled their older equipment and eliminated a problematic 3rd shift while increasing total output, profitability and quality.

Conclusion

Whether you decide to automate because of the application, or because of efficiency, it is critical to spend the time to learn the real costs of your current operation and the real long-term benefits of automation. Every dollar spent now on speed and efficiency will have a cascading impact on the profitability and viability of your business in the future. The cost of labor in the U.S. will not decrease. Pressure from overseas markets will have a profound effect on your customer base. You must take advantage of the only edge available and embrace products that help you not only survive but grow a sustainable and profitable business. Plus, don't forget, going fast is fun.

10. Artwork and Film

The quality of the original artwork and the quality of the film positive generated from that artwork will determine whether you succeed or fail in cliché making, since there is nothing you can do in the cliché making process to compensate for poor quality artwork and film.

What constitutes quality artwork?

For pad printing we need to have vector graphics. Unlike JPEGs, GIFs, and BMP images, vector graphics are not made up of a grid of pixels. Instead, vector graphics are comprised of paths, which are defined by a start and end point, along with other points, curves, and angles along the way. A path can be a line, a square, a triangle, or a curvy shape. These paths can be used to create simple or complex drawings. Paths are even used to define the characters of specific fonts. When paths come together to create a “closed” image, they can be filled uniformly, or with gradients and texture.

Because vector-based images are not made up of a specific number of dots, they can be scaled to a larger size and not lose any image quality. If you “blow up” a JPEG will look blocky, or "pixelated." Vector graphics can be made larger, or smaller, while high resolution. This makes vector graphics ideal for logos, which can be small enough to etch or engrave into a cliché plate for pad printing, but can also be scaled to fill a billboard. Common types of vector graphics include Adobe Illustrator (.ai), Macromedia Freehand, and CorelDraw (.cdr) file.

CAD (.dwg) and other two or three-dimensional data files are not useable, since they have segmented lines and cannot be filled as required to create the films we need for making cliché plates. Data files such as those have to be imported into a graphics program such as Adobe Illustrator or CorelDraw and redrawn from scratch. If you don’t have vector graphics, expect to pay your cliché supplier for their graphic artist’s time to create them.

Graphics Software

There are many programs that can be used to generate and manipulate graphic files.

I prefer CorelDraw because you can save color separations as separate pages of a single file, whereas in Adobe Illustrator you need to save each separate page as a different file. I also like it because it is what I originally learned back in the 1980s. To me CorelDraw is like a “first language”, with Adobe Illustrator being like a second language in which I am not as fluent.

One benefit of Adobe Illustrator is that it allows you to import portable document files (.PDF) as “native” files, which means that the graphics automatically appear at the correct size. For example, if you have a master graphic file that shows the outline and / or features of the part, along with all of the various graphics in their correct location and orientation relative to the part features, you can use Illustrator to measure the exact distance from the feature to the graphic. This can be very useful when the customer doesn’t have a dimensional drawing that clearly indicates graphic locations relative to features of the part you’re printing.

CorelDraw doesn’t always import at the correct size, so it is sometimes necessary to scale them. Additionally, Adobe Illustrator is compatible with MAC, whereas with CorelDraw, you need a Windows operating system. Some people use both on a MAC by setting up a partition which allows them to use both operating systems.

Creating Film with an Image Setter

For best results it is necessary to have a film that is produced by an image setter (or photo plotter).

An image setter / photo plotter is a high resolution output device that can transfer electronic text and graphics directly to offset film, plates, or photosensitive paper. It can be thought of as a very expensive high resolution printer and can come in many different sizes and formats. An image setter uses a laser and a dedicated raster image processor (RIP) and is usually PostScript -compatible to create the film used in computer-based preproduction work. Unlike the resolution on a home printer, which is probably between 300 - 600 dots per inch (dpi), the resolution on a typical image setter is 1270 or 2540 dpi with a maximum dpi of 4000.

We use a film bureau for film. We send them our vectorised graphic files (with all text converted to curves), in a template (or templates if it is multiple color) and they output the using a laser plotter, using one of several different types of film (Kodak, FUJI) that are extremely dimensionally stable, as is required for high quality pad printing.

Creating Film with a Laser Printer

If, however, you're using photopolymer clichés to print you might be able to get by with a good laser printer and a film media specifically designed for use in making "film". The image resolution won't be as good as an image setter / laser plotter will produce, the image won't have as high density (level of opacity), and the film itself won't be as dimensionally stable, but if your tolerances allow for some latitude, it probably won't matter.

When I am making prototypes I use a frosted, polyester film from TOSH and a desktop HP LaserJet. Different brands of laser printers have different "fill protocols" or methods of creating the outline and fill for graphics. Some laser printers don't fill as solid as others, so it is incumbent upon you, if you're going to use a laser printer to make film, to do some research before buying. If possible, take a PDF into Staples or Best Buy and ask them to output it from various printers using your film media. Or, ask friends with different laser printers to print them, then compare them to see which brand / model fills the graphics in the most opaque manner. You can do that by holding the films up to light source, over an L.E.D. or flashlight bulb, or with a densitometer, if you have one available.

Most printers can be set for 300, 600 and 1200 dpi. I've found that the output resolution should be set to 600 dpi for best results. 300 puts more toner down, but the resulting definition on the edges of the graphics suffer. 1200 makes the edges smoother, but doesn't put down as much toner.

I also use a spray to enhance the density of the resulting films. I prefer a product called LaserBlack, from Innovative Marking Systems. LaserBlack contains a proprietary blend of solvents specifically formulated to make the toner more opaque without changing the dimensions of the graphics themselves. You simply spray the image area and allow it to dry.

Film Orientation

The orientation and density of the image on the film are extremely important.

Film orientation terminology can be confusing since different printing processes require different orientations.

Film orientation is important regardless of what method you are using to create film positives. In pad printing you always want the emulsion (or toner) to be oriented so that it will be in intimate contact with the cliché during exposure.

The correct orientation for pad printing is "emulsion down". That means that as you are looking at the film or laser printed media the emulsion, or toner, is on the back side of the film / sheet when the image is as it should appear after printing.

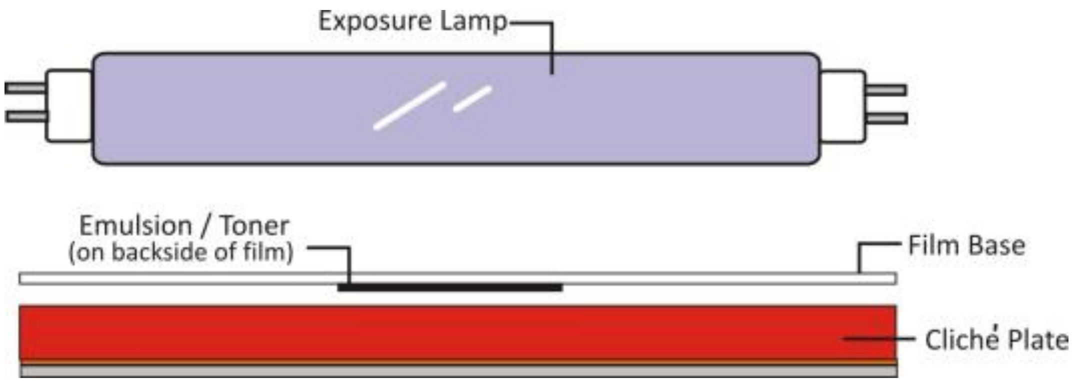


Illustration by John Kaverman

When creating positives with a laser printer on vellum it is necessary to print a mirror image so that once you place the vellum image down on the cliché the toner will be against the cliché surface. You can do that by either reversing the orientation with your graphics software, or possibly with your laser printer's software.

Image Distortion

Although the pad distorts over the surface of the substrate in pad printing, distortion of the artwork is sometimes necessary. Printing on compound angles, raised surfaces, up sidewalls and over edges are just a few examples of where it may be necessary to distort artwork.

There are a couple of tricks that you can try to save time in deciding just how much to distort, and where.

Print a Grid

1. Make a cliché of a grid pattern. The size of the grid depends upon the size of your image. I use a grid about 5 mm. square. Print the grid on the part in the correct area. You may want to try a number of different pad shapes and sizes to find the one that distorts the least. Once you have the best

printed result, use that part as a guide, distorting your art-work as necessary one square at a time. Make sure to keep good notes on which pad you used, where it touched down on the part, and how far it is compressed.

Reverse print

2. For printing on raised letters I use a method that I call "reverse printing". Nest the part and set up your pad to compress over the entire area to be printed. Tape a piece of paper where your cliché goes. (Tape it on a blank, or on the back of an existing cliché so it is flat.) Lightly paint or cover the raised letters with ink, then compress the pad on the part to pick up the image and print it on the paper. This creates a print of the raised letters that shows the distortion. You may even scan that in to your computer and draw over it to create artwork.

Layout

When laying out the artwork to the cliché be careful not to exceed the cliché and / or the machine's maximum print area. In open systems avoid using more than 80% of both the length and width dimension. On many machines, anything outside of 80% either doesn't doctor very well, or is too close to the edge, resulting in the pad picking up unwanted ink. On closed systems, avoid using more than 85% of the ink cup's diameter. When exceeding these recommendations, you may end up picking up and transferring extraneous ink from the edges of the doctored areas of the cliché.

The direction the machine doctors also needs to be taken into consideration when laying out artwork for open inkwell systems. If your artwork has straight lines, try to lay it out so that those lines are either perpendicular to the doctoring direction, or at least at some angle just off perpendicular. You want to present the etched image to the doctor blade at the narrowest possible perspective.

It is always a good idea to double check the orientation of the image as it will appear on the cliché prior to etching it. I like to lay a laser print or full sized sketch of the artwork on a table with the nesting fixture(s) or part(s), preferably at the correct stroke length (and on multiple color machines, cliché centerline to centerline dimensions) to see if everything is going to line up. If you're clever, you can also do this in your graphics program by creating a template that shows your individual cliché dimensions, center-to-center distances between the clichés / images for multiple colors, and the centerline(s) for the nesting fixtures on your part conveying system.

Creating Templates and Color Separations

Today electronic files are easier to obtain from your customer than anything resembling actual camera-ready artwork. If you have a process camera, and you can get your hands on camera-ready artwork, producing an emulsion down film positive should be a "no-brainer". My experience in recent years indicates that electronic artwork is most frequently going to be the first option. Having a good graphics program that can import various types of files without significantly modifying the files is very important. The degree of flexibility your software needs depends on the number of industries you deal with, since different industries favor certain formats.

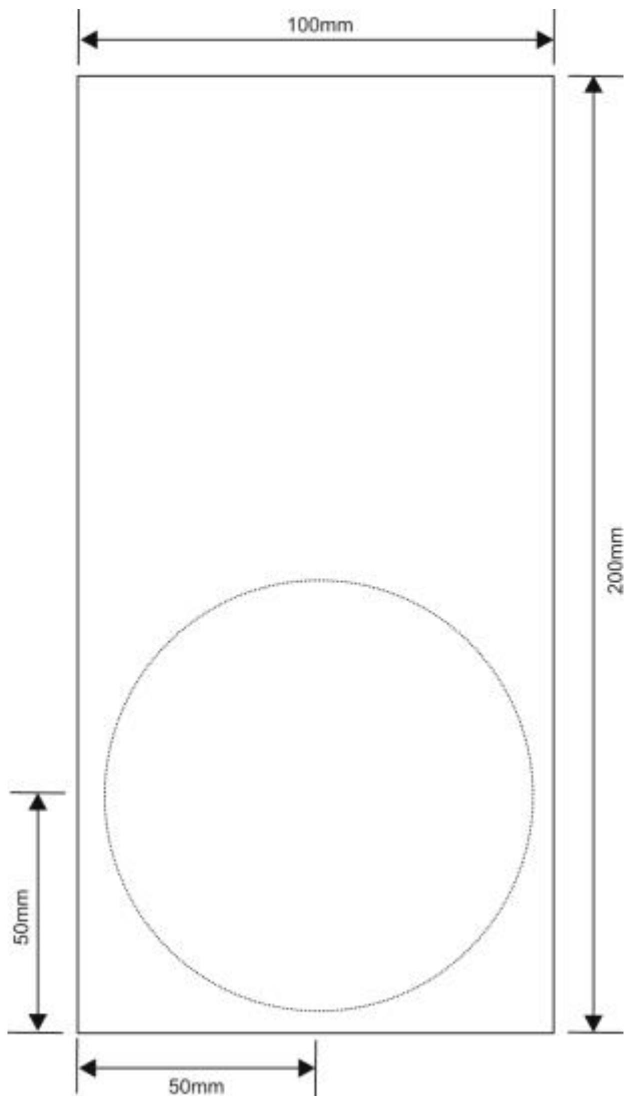
Popular graphics programs include Adobe Illustrator, Corel Draw, and Freehand. I'm not a software guru, but I know from experience that Illustrator and Corel Draw are powerful and versatile. Both have strong file import and export capabilities, as well as useful tools for manipulating scanned images and photos.

CAD programs and their resulting files are not very useful for making clichés. These programs don't provide images with smooth curves or solid fills, nor do they usually import into a graphics program with good results.

Creating Templates and Color Separations

For our example we will prepare films with a PC based graphics program and a laser printer using the following method:

First, create a template of the actual cliché.

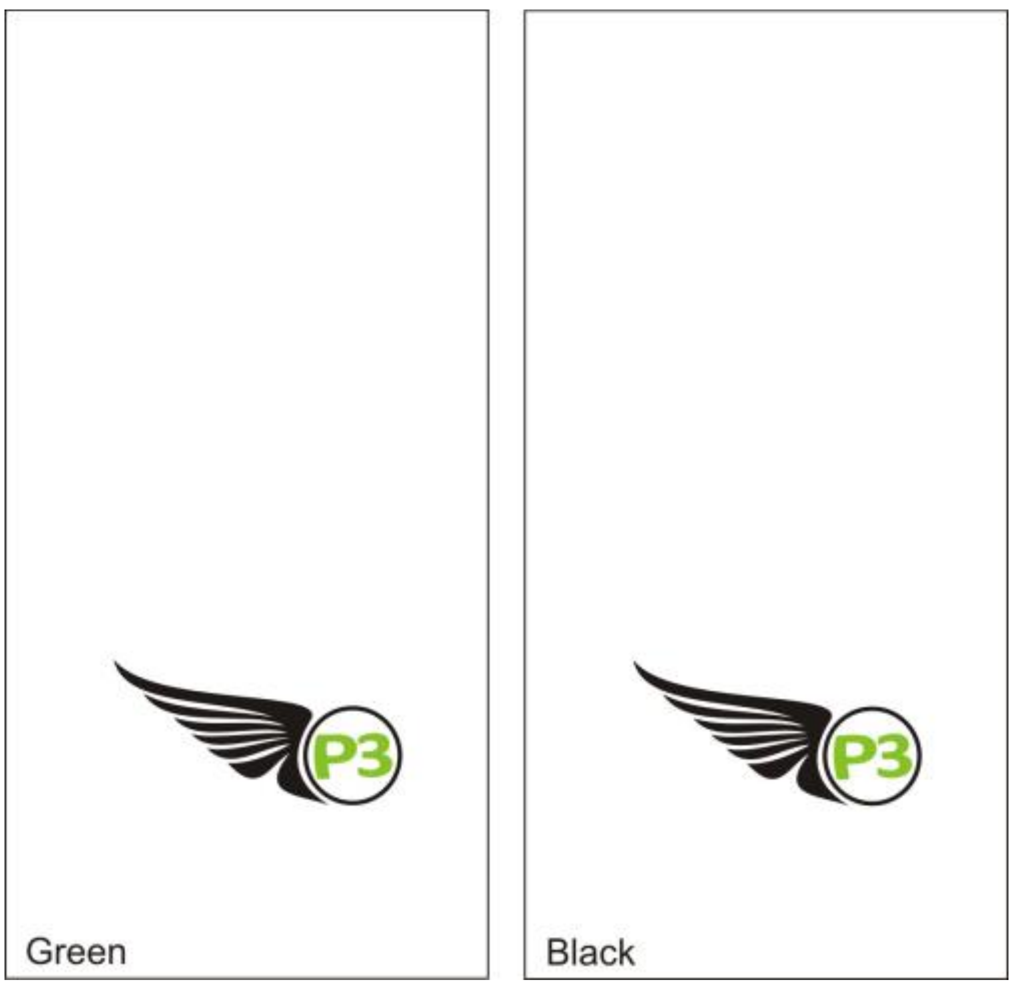


The sample template above is not to scale on this page, but it is for a 100mm x 200mm cliché. The 90mm ink cup diameter is indicated by the circle with the dotted line. If I wanted to locate the graphics in the center of the ink cup, the "setback" would be 50mm from the front edge of the cliché, and 50mm from the side.

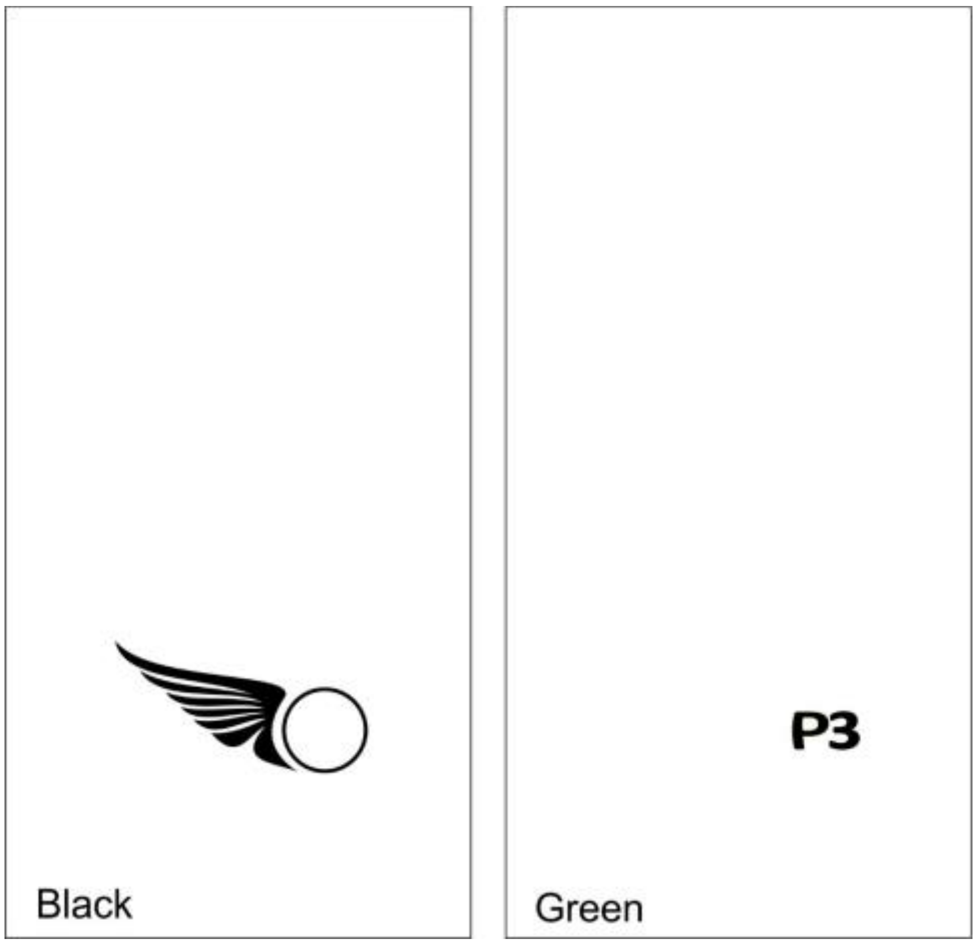
Having templates like this, for each of your cliché sizes, is a good idea. That way you can quickly import the client's graphics, position and orient them, as I have done with the Pad Print Pros, LLC (my company) logo below.

Once you've got your artwork in your template where you want it, you need to duplicate the template, with the full color graphic, one time for each color separation required. For this example, I have a two color graphic: the black wing and circle, and the green P3.

I've also gotten rid of the ink cups outline, and noted which color each cliché will be for, outside of the ink cup's doctoring area, for both my own us in separating the colors in the next step, and for reference when setting up the pad printing machine later. Some people also include a job number or file name on a corner of the cliché for filing purposes.



The next step is to ungroup your two duplicate images and delete the respective colors to create your separations, replacing the color fills with black.



At this point you may or may not be ready to output the file to the image setter or laser printer. It depends on whether you need to reverse the orientation of the graphics in your graphics program, or in your output device's software. Either way, you want to end up with your images "emulsion down" (or on the back of the film base as you're looking through it), as illustrated earlier in this chapter.

P3

Green

Black

11. Cliché Plates

The cliché plate is where the pad printed image begins its journey.

There are four basic types of clichés: solid steel, thin steel, laser and photopolymer.

10mm Thick Steel Clichés

Provided they are used and stored correctly, 10mm thick steel clichés can be expected to last in excess of 1 million impressions. Typical etch depths on steel clichés are 18 to 25 microns. (About .001") In some cases they are etched deeper to allow for a thicker ink deposit, but etch depths in excess of 30 microns are not recommended for normal applications.

The steel used is usually an A2 or D2 grade, with varying levels of chrome content. For example, there are no-chrome, low-chrome and high-chrome steel clichés. The higher the chrome content, the higher the resistance to oxidation. The lower the chrome content, the better the resolution.

Several manufacturing steps must take place before the steel is ready to be made into a cliche. It must be cut to size and squared, usually using an end mill. After being cut and squared it is generally necessary to grind them flat or parallel. After grinding they are hardened to 62 -64 Rockwell (C-scale), and finally, lapped smooth. Normally only one side is lapped, since most pad print machine designs do not allow a cliché to be affixed without potentially damaging the back side of the cliché.

Steel clichés are coated with a photosensitive emulsion (or photo resist) and dried. The coating process is very important, since you want the coating's thickness to be very consistent. I have seen people apply photo resist by spinning the cliché on a turn-table, by dipping them, by spraying them, and by applying the resist as a laminate film.

A clear film with the image to be printed is placed emulsion down on the cliche and an exposure is made using U.V. light. If the image requires a line screen (there is a lot more detail on line screens later in this chapter) a second exposure is made. Next, the cliche is developed and allowed to dry. Sometimes the developed and dried clichés are touched up with a chemically resistant lacquer and dried again. Finally, the cliche is etched in a ferric chloride or nitric acid bath for a specified time, at a specified temperature, and with a specific degree of agitation. After etching, the cliche is cleaned with a solvent to remove the photo resist and touch up lacquer.

Because of the number of steps involved in the process of making steel clichés, and the environmental ramifications of having many of the related chemicals around, solid steel clichés are usually made by pad printing equipment manufacturers and distributors in their facilities.

While a lot of companies still use 10mm thick steel clichés, they are becoming less popular, mostly due to their higher costs and the fact that there are not as many applications around anymore that require millions of impressions on anything.

Thin Steel Clichés

Thin steel clichés are flexible steel plates, usually about 0.5 to 1.5mm thick, depending on the manufacturer. They are also referred to as "record clichés" or "mid-run clichés". Thin steel is less expensive and less durable than solid steel. A thin steel cliché may last anywhere from 35,000 to 150, 00 impressions or more, depending upon the type of image etched, the type of machine used, and several other variables.

Being thinner than solid steel, it is necessary to attach these clichés to some type of holder or "dummy plate" to bring it up to the correct height for doctoring. Some manufacturer's "dummy plates" use magnets, locating pins, or a combination of the two to attach the thin steel clichés. Other manufacturers use a spray adhesive or double-sided tape with a blank steel or aluminum plate. Magnetic plates, or at least precisely machined steel or aluminum plates with pins are preferable over using spray adhesive or double-sided tape. Spray or tape can cause the cliché to be out of parallel resulting in problems with doctoring in either an open inkwell or sealed ink cup machine.

Thin steel is etched to the same depth as solid steel, and can have screened images if necessary. Since the etching process it the same as solid steel, manufacturers and distributors make most thin steel clichés.

Laser Engraved Clichés

Until fairly recently I wasn't a proponent of laser engraved clichés because all of the laser clichés that I had seen had been created using low-end, laminated cliché media and CO_2 lasers that were lacking when it came to their capabilities to produce high resolution and consistent etch depths. The results were just "good enough", as long as the resulting prints weren't expected to be on par with what I considered to be "highly aesthetic".

In 2010 I learned that there are laser engraved cliché materials that can produce phenomenal results using both CO_2 and YAG lasers.

Solid Ceramic Clichés

Ceramic clichés, which are made of the same type of ceramic that many manufacturers use for their doctor rings, are engraved with YAG lasers. Ceramic clichés provide excellent resolution, consistent etch depths, and can have a service life of several million impressions. The problem with ceramic clichés, however, is that they don't work like they are supposed to if you are using an ink cup that uses magnets to obtain a hermetic seal with the cliché, and they are brittle / easily damaged if handled carelessly.

High-Tech Ceramic Clichés

"High-Tech" ceramic clichés are essentially aluminum plates that are coated on both sides with ceramic. Lighter and significantly less brittle than solid ceramic clichés, these can be engraved on both sides with excellent results, with each side lasting for upwards of 2 million impressions, assuming once again that you're using them in a machine with a doctoring system that is designed without magnets in the ink cups.

Aluminum Oxide Clichés

Aluminum oxide clichés are (you guessed it) made of aluminum which has been chemically treated, creating an oxidized layer. The chemical treatment seems to produce a coating that has a consistent thickness, and is very durable, provided the cliché is not bent. When bent, you can hear the oxide layer fracturing like glass, and the clichés must be discarded.

Unlike ceramic clichés, aluminum oxide clichés can be made with magnetic ink cups by laminating the thin aluminum media to a steel backing.

Laminated Clichés

There are a lot of laminated cliché materials out there that are intended for use with CO_2 lasers. I've seen some good ones that produced 1200 dpi resolution in printing process color (CMYK), and I've seen some bad ones that produced poor quality images.

Pre-exposed Photopolymer Clichés

Some pad printing distributors are selling pre-exposed photopolymer cliché materials for use with laser engraving systems.

Laser Engraving Systems

Not all CO_2 or YAG lasers are well-suited for engraving clichés. The success or failure of any laser system has as much to do with the raster image processing (RIP) software as with the laser beam itself. The RIP software is what essentially translates the vectorised artwork file into the laser's language, similar to the way your desktop laser printer's driver software translates the file you're printing from Microsoft.

Not all RIP software is created equal. Someone explained this to me using the analogy of a language translator. Good RIP software is like a translator who is fluent in, for example, English and Spanish. Bad RIP software is like a person with a picture dictionary, pointing and making gestures in an attempt to communicate complex information.

It is incumbent upon the buyer to thoroughly test any laser engraving system with their desired cliché materials before purchasing. That means having the laser manufacturer or distributor take your vector graphics and engrave them for you so that you can physically put them in your pad printer and print them.

Photopolymer Cliché Materials

Now let's consider photopolymer cliché materials. Photopolymer clichés consist of a resistant layer of photosensitive material anchored by an adhesive layer to a steel base plate. The steel base plate allows the cliché to be easily affixed to the magnetic cliché holders used by most pad printing equipment manufacturers. The photosensitive surface of the clichés come covered with a protective foil, and should be packaged in a U.V.-protective bag. Packaging should not be opened, nor should cliche blanks be handled except under lighting that has filtered to exclude U.V. wavelengths. You don't need to work in "darkroom" conditions (red light). Standard florescent bulbs can be shielded with special sleeves. These sleeves can be purchased from office environment suppliers and allow you to work in normal colored light, without the U.V. component.

Cost, durability and image resolution can vary significantly from one type of polymer material to another. Some photopolymers are developed in water, and some are developed in alcohol. Water developed clichés are usually less durable than their alcohol developed counterparts, but not always. It depends on the manufacturer.

The thickness of the base material and adhesive layers, and the type and thickness of polymer used can all vary significantly from one manufacturer to another and even from one type or series of material to another from the same manufacturer.

Base material thickness can be important depending upon the method used to attach the cliché to a base (or "dummy") plate for printing. Most pad printing equipment manufacturers attach the polymer cliche to a magnetized steel plate with some type of locating pin system. Other manufacturers may use screws, double-faced tape, or spray adhesive. As I mentioned earlier in the chapter, precision-machined magnetic plates work better because they are generally easier to affix polymers to, especially when they incorporate a locating system. With this type of system you can use just about any thickness without experiencing problems relating to the cliché's ability to lay flat without slipping (as in the case of tape or adhesive) or deflecting (as in the case of screws). If you have to use something other than a magnetic plate, I recommend using a polymer with the thickest possible base.

The adhesive layer determines how well the polymer material sticks to the base material. The thinner the adhesive, the better the chances or the polymer releasing from the base near the edges of the cliché when they are sheared to size and punched for locating pins. This rarely has anything more than a cosmetic effect, unless the loss of adhesion is severe, in which case the polymer material has probably exceeded its shelf life or been subjected to extremes in temperature and humidity.

The specific type of polymer material and the thickness of that material have the biggest effect on the durability and image resolution of the finished cliché. Polymer materials have different molecular structures.

When these materials are exposed to UV radiation the molecules align to form chains (polymerization). The length of the resulting chains determines how dense and / or hard the finished cliché is. High quality polymer materials can withstand more than 100,000 impressions, with an image resolution that meets or exceeds that of etched steel and engraved laser clichés. Lower quality materials may only last for several hundred to a few thousand impressions, with a lower quality image resolution. Rule of thumb is that the higher the quality and the thicker the material, the better the resolution and durability.

I've work we have three types of popular alcohol developed polymer materials. All three have the same base material and adhesive thickness. One material is about 30 microns thick, another 40, and another about 50.

The 30 micron material is what we refer to as a "one-step" cliché. It requires only one exposure prior to development, has a large exposure window (acceptable range of exposure times to yield the same result), and produces a pretty consistent etch depth. For really, really tiny print (for example, the tick marks on a chronometer), one-step clichés can be too deep, resulting in the line width of the printed image being too thick.

The second two materials require two exposures. The first exposure is made with the artwork. After replacing the artwork with a line screen film, a second exposure is made.

The second exposure has several purposes. First, it controls the amount of ink that is present within a given area. Second, it forms a dot pattern in the image area that supports the doctor blade in open inkwells, and the doctor ring on sealed ink cups, minimizing the chance of the ink being scooped out of the etch during doctoring. Third, it gives the ink some resistance to flow when the pad is compressed onto the surface of the cliché, minimizing the chances of the ink being "squished" out toward the edges of the image from the center by the transfer pad during image pick-up.

While the "one-step" materials may be easier to prepare, they have limited use due to the fact that the image area cannot be screened to prevent the doctor blade or ring from scooping ink out during doctoring, nor can the etch depth be varied significantly. Translation: they work well for fine copy, but not for bold text, images with large open areas, or images with a combination of both fine and bold areas.

Line Screen

Materials that require two exposures (commonly referred to a "screened" clichés) are more versatile. By varying the line screen you can control not only the image resolution, but the amount of ink that you can transfer as well. Typically we recommend a 120 line per centimeter (300 line per inch) screen with a 90% dot for most applications. However, if we need to increase (or decrease) the ink film's opacity for a specific application (like four-color process) we can use another line screen.

The higher the line-count (more lines per cm / inch) the higher the resolution and the less ink volume. Contrary to popular belief, it is difficult to accurately control etch "depths" in polymers by varying the exposure time. While it is true that polymers cross-link from the bottom-up, theoretically allowing you to reduce etch depth by increasing exposure time, in reality the theory is easier than the practice. On the other hand, using varying line screens allows you to accurately control the *volume of ink* that can be contained within a given image area. This results in better control. For example, a 120 line per centimeter screen with a 90% dot (90% opaque, 10% open dot) will produce a pattern of 120 microscopic "peaks and valleys per linear centimeter. By contrast, a 100 line per centimeter screen also having a 90% dot will produce 20% fewer peaks, and 20% larger valleys, thus enabling the same image area to "hold", theoretically, 20% more ink. If 20% isn't enough, try an 80 line / cm screen.

The following chart shows popular line screens (metric and English) and the respective type(s) of clichés they are suitable for use with.

Line Screen Conversion Chart

Cliche Type	Lines / cm^2	Lines / $inch^2$
Steel Only	54	137
Steel or Polymer	80	200
Polymer Only	100	250
	120	300
	150	380

There is a point, or depth, where it becomes impossible to effectively pick up and transfer the ink. When clichés become too deep the ink in the etch has a hard time achieving the necessary level of cohesiveness, so you either end up picking only a portion of the ink up (as an inconsistent layer), or you end up transferring only a portion of the ink to the substrate. If the ink cannot achieve cohesiveness in an acceptable amount of time, and without the assistance of blowing over the cliche and / or part, it is probably because the etch depth is too deep.

The ink's ability to rapidly change physical characteristics is what makes pad printing work. An ink that cannot change (i.e. ink without a fast evaporating thinner, such as water-based and U.V. inks) is difficult, or impossible, to efficiently transfer. We will discuss that in more detail in the chapter about inks.

Which type of polymer cliché is right for your application? Nine times out of ten I reach for the highest quality, screen-able material. The combination of best durability, better image resolution and a consistent performance make it the logical choice. While on the surface the higher price of the material may appear to be prohibitive versus a one-step or lower quality screen-able material, it really isn't. Why? Labor. Look at it this way. You're going to spend the same amount of time making the cliché regardless of what material you use (minus a few minutes if you use a one-step material). However, you're going to spend less time getting the cliché to doctor cleanly with the higher quality material, you're going to get a better quality image, and the cliché is going to last a lot longer.

For example, let's look at the 70 X 150 polymer cliché we made the template for. Say that the 43 micron thick blank costs you $ 2.00, and the 52 micron thick blank costs you $ 5.50. A difference of $ 3.50. The artwork, film and labor to make either of the two is equal. Now, consider that the 43 micron material lasts 40,000 impressions, while the 52 micron material lasts closer to 100,000. With the higher quality material you can make your 300 samples, plus the 75,000-peice production run with the same cliché. Cost of cliché only: $ 5.50 divided by 75,300 pieces = $ 0.000073 per part.

With a "cheaper" material you'll have to make at least two clichés, doubling the cost of the material and the labor. So, if you figure your time is worth a conservative $18.00 an hour, and your using an extra 1/2 hour to make the second cliché, your cost for using the "cheaper" material is $ 4.00 (2 clichés) + $ 9.00 (additional time it takes to make the second cliché) or $ 13.00. Divided by the same 75,300 pieces = $ 0.000173 per part. So, in reality, the "cheaper" material ends up costing you $ 7.53 more than the more expensive material over the length of the job. In reality, the "cheaper" material isn't really cheaper.

Rotary Clichés

Clichés for use on rotary pad printing machines are typically either solid steel or ceramic "drums", or polymers clamped to a drum. There is a keyed hole through the center for mounting either type to the appropriate shaft.

Multiple Images on One Cliché

It is quite common (but not recommended) for closed system clichés to have an image etched on each end, especially when the ink cup strokes to far enough to cover images at both ends. If the cup only strokes far enough to the rear to cover a portion of the image on the back ink can leak out. If the leaked ink builds up and dries it can cause a real mess. If the machine only strokes far enough to the rear to partially cover the image, the wear pattern that develops over time may result in your picking up ink from the wear pattern when trying to use that image. Plus, it will leak a lot because when it bisects an etched area of the cliché ink wants to flow out from under the doctor ring.

The reason I don't recommend it is because of the additional potential for leaking and solvent loss, as well as the fact that when you're doctoring to print from one end of the cliché you're still wearing the other end.

Mounting Thin Steel and Polymer Clichés

When mounting thin steel and polymer clichés to dummy plates, magnetic or otherwise, make sure your dummy plate and cliche are clean and free debris before sticking the two together. Any debris in between the two that results in a "bump" can cause irreversible damage to the cliche when the machine doctors.

When mounting thin steel clichés to a non-magnetized dummy plate you can use spray adhesive or double-sided tape. In either case, be sure the adhesive you apply is as consistent in thickness as possible so that the cliché will be level once attached.

When mounting polymer clichés to a non-magnetized dummy plate a light over-spray layer of adhesive is recommended instead of tape. Any gaps between rows of tape or overlaps will be more evident with polymers because they are so thin and flexible.

I don't recommend using spray adhesive or tape to affix clichés to a base / dummy plate. They always end up being out of parallel. I recommend always using a magnetic base plate with a pin registration system.

Frequently Asked Questions Regarding Clichés

Why screen an image in a cliché? There are a number of reasons. First, most large open areas in images need to be screened to support the doctor blade or ink cup from dipping down into the etch during the doctoring stroke. The little dots resulting from a screen exposure end up being little "hills" in the bottom of the etch. These little hills provide additional surface area for support of the blade or cup, preventing them from dipping down into the etch and pulling the ink out from below the level of the top surface of the cliché. This ensures that you get a consistent ink thickness to pick up with the pad, instead of one thick on the edges and thin in the middle.

Second, those little hills provide resistance to the flow of the ink when the pad compresses to pick up the image. In large open areas the pad can produce a wave action in the direction it is rolling during compression. The screen gives the ink something to hold on to in the bottom of the etch until it is picked up by the pad, so that you get a nice consistent ink thickness.

Screened images can be etched in solid steel, thin steel, and some polymer clichés. What constitutes a "large open area" depends upon several variables other than dimension. The desired depth of the etch, the speed at which you stroke the machine, the type of doctor blade you use and how much pressure you apply to it, and the angle of the image in relation to the stroke of the machine all make a difference. The people who make your clichés need to know as much about how you intend to use it as possible to help you determine whether you need to screen an image or not, and if so which type of screen to use.

Why isn't it recommended to images on both ends of a cliche for use in sealed ink cup machines? Theoretically the ink could lose solvent faster because you are evaporating solvent from the ink contained in the etched image on the opposite end from the image you are printing while the machine is in production. Also, you aren't "saving money" by having an image on each end because while you are printing using one end you are still wearing the other end, so instead of getting a million prints from each image the cliche wears out at 500,000 prints, or half the time that would otherwise be expected.

Can I have an image larger than my ink cup? It is sometimes possible to have the image be larger than the ink cup, provided that the cup will still doctor over the entire image and far enough beyond to allow the pad to pick the image up without interference. This is tricky and requires some careful planning in the layout. In any case, you don't want the ink cup to bisect a graphic, or you'll increase the potential for loss of solvent and / or ink through the etch.

Can I put a bunch of small images in my ink cup? For printing small images, like names on key chains for example, it is possible etch several names on one cliché, then change the location of the pad and the nest for each name. By using pins to locate both the pad and the nest to pre-determined points that correspond with the location of the individual names on the cliché, change-over times can be as short as a few seconds. This works well if you're printing different names on identical products, like souvenir key chains or magnets. This method requires extreme attention to detail in the layout of everything involved. Using the round cliché for this application is easier, since you only need to spin the cliché to get a new image. The choice depends upon how many names you have to print versus how many names you can fit on the cliché.

Unless the job you're considering allows you to print a high enough volume of parts to justify the expense of tooling up to print using one of the methods I've just mentioned, it is best to consider another marking process.

Cliché Plate Life

Cliché plates wear out. I am asked by nearly every client that I talk to, "How long do the clichés last?" There is no definitive answer, however the following chart illustrates what is reasonable to expect from you clichés as far as the number of cycles / lifetime. Remember, this is cycles, not impressions. That means if you are double printing, the number is really half of what the chart shows. Additionally, if you're using a doctoring mechanism that is constantly doctoring (for example an X-axis doctoring device), you might be subjecting the cliché to five or more cycles per impression.

Typical Cliché Service Life

Cliché Type	Number of Cycles
Water Wash Polymer	10,000
Alcohol Wash Polymer	20,000
One-step (no screen) Polymer	6,000
Thin Steel	80,000
Thick Steel	1 million
Low-grade, laminated (laser)	10,000
Aluminum Oxide (laser)	80,000
Ceramic (laser)	3 million +
High-tech Ceramic ((laser)	3 million

Note: Cliche service life may be higher or lower, depending upon several variables including but not limited to specific pigments and ink additives, volume of ink used in the ink cup, machine speeds, line screen, amount of force applied during doctoring strokes, and more.

Cleaning Cliché Plates

All types of clichés, especially clichés with a line screen, should be cleaned with a thinner suitable for the ink that you're using. I prefer to use retarder (slow thinner), since it can sit on the image area for an extended period of time and will not evaporate.

After you're done rough- cleaning the cliché with whatever you use (thinner, acetone, cleaning solvent) you should go back and clean the etched image area again using the following method:

1. Apply some retarder (slow thinner) to the entire image area using a pipette or eye dropper. Use enough to make a puddle that covers all of the image areas.

2. Allow the retarder to sit there for several minutes. This will allow the small amount of ink that is commonly left behind by the initial cleaning to dissolve and go into suspension (float out of the etch).

3. Apply some retarder to a clean tissue and gently wipe the image areas in a circular motion.

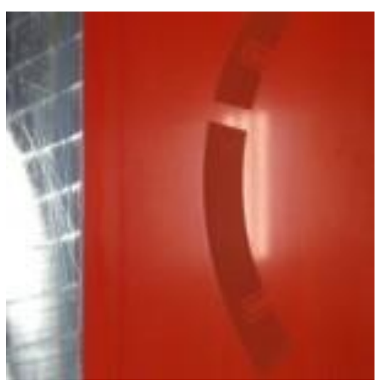


Image area after initial cleaning with acetone.

Image area soaking in retarder for a few minutes.

Image area after being soaked with retarder and wiped clean.

Many of the cliché plates that I looked at were damaged from having had debris between them and the cliché holder (aluminum block with pins that the cliché attached to). It is essential that the back of the clichés and the cliché holder be cleaned to remove all old ink and / or other debris.

Anything in between the cliché and the holder (I've seen eyelashes cause the problem) will make the cliché have a slight "bump" on the surface. Once the ink cup is installed and the machine is doctored, the doctor ring will shave the top of the polymer off the cliché. Once the cliché is removed and the debris falls out, the cliché will have a depression / low spot on subsequent jobs where ink will not be doctored. If this is in or near the image area, you will have to replace the cliché.

Handling and Storing Clichés

Clichés should be stored either vertically, like books, with space in between or lying flat with the etched image up to avoid scratches. Clichés should never be stored stacked on top of one another.

Solid and thin steel clichés should be coated with lightweight oil to prevent rust during storage. All clichés should be kept as clean and dry as possible. Air-tight containers are nice, but not necessary unless you are in a humid environment or operating across the street from the ocean where the salty air corrodes things faster than normal.

Some thinner can corrode the surface of steel clichés if left to sit for extended periods of time, like over the weekend in a closed ink cup. Check with the ink supplier to see if any thinner you're using is corrosive.

Always be sure the cliché is clean before you put it away, especially if you're using two component ink or a cliché that has screened images. Dried two component ink in a screen image is very difficult to remove without damaging the cliche.

12. Polymer Cliché Exposure and Development

Polymer cliché materials have come a long way in the last ten years. A well-made polymer can provide excellent results, while an incorrectly exposed and developed cliche can cause headaches.

Let’s take a look at photopolymer cliché construction.

Polymer Cliche Construction

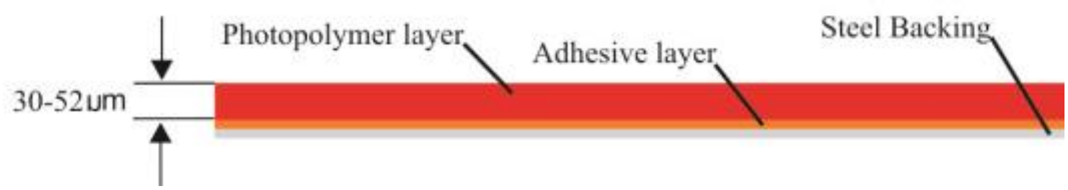


Illustration by John Kaveman

The thickness of the polymer layer varies from about 30 to 52 microns. A micron is 1 millionth of a meter (or 1/1000th of a millimeter = 0.001mm, or equivalent to about 0.000039”).

Making photopolymer clichés consistently is a simple process, with fewer variables than one might expect. The trick is eliminating as many of those variables from your process as possible.

Polymer Cliché Making Environment

What do you need to correctly expose and develop photopolymer clichés? First, you need an environment to work in that is free from U.V. light.

Photopolymers are sensitive to U.V. light wavelengths, so you need to prepare a space where you can safely handle unexposed clichés. Overhead florescent lights, most incandescent (light) bulbs, and natural sunlight coming in through the windows can all expose photopolymer clichés if you aren’t careful.

Choose an interior room, so you don't have to worry about natural light. If you have typical overhead florescent lights I recommend shielding the individual bulbs with U.V. filtering "sleeves" that slide right over the tubes. These are nice in that they allow you to use standard U.V. light bulbs for your cliché area, and because they enable you to work in the same lighting that you're used to. U.V. filtering tubes can be purchased in varying lengths from many office supply and furnishing suppliers, or go online. I Googled "UV sleeves for florescent lamps" and found pages of suppliers in seconds.

If all you have is a regular old light bulb or bulbs, you may be able to get away with simply replacing the regular bulb(s) with one of those yellow bulbs that you would use to light your porch without attracting insects. You can get them at most any box store. They are coated to remove the U.V. wavelengths from the light, which is why bugs aren't attracted to them. The problem with those bulbs, however, is that they require that you work in yellow light. Google "yellow bug lights".

You will also need a couple of tables, and probably a file cabinet to keep your blank clichés, films and other stuff in. Many people use hanging folders to store clichés of smaller dimensions.

Finally, if you are going to manually develop your clichés, you will need a shallow, covered, plastic tote that is large enough to easily accommodate your largest cliché size. Rubbermaid makes lots of containers, available at box stores. You will also need a few of those little fuzzy paint pads from the box store, like the one pictured below.

paintbrushesandrollers.com

Cliché Exposure Unit

Exposure Unit

Photo: TOSH

You will need an exposure unit. Most pad printing equipment manufacturers offer some type of exposure equipment. The cost of exposure equipment is directly proportionate to the size of cliché you need to make. Small units start out around $500.00, while larger units can be $3,000.00 or more.

Features to Look for in an Exposure Unit

1. Vacuum is a huge plus, as it ensures a good contact between the cliché and the film during exposure. Insufficient (or no) vacuum will invariably cause poor contact, which results in uneven etch depth, poor image resolution, or both.

2. A light source with low wattage, U.V. output having a wavelength of 350 to 400 nanometers. Lower wattage (20-40W) is necessary to have control over the length of the exposure. Note that when you double the wattage of the light source you don't use ½ the exposure time, you use the square root of the exposure time. Therefore, a 1000W screen exposure unit would be much too powerful to allow you to have any control over the exposure time… which would have to be a few seconds, or fractions of a second.

3. An accurate timer is a must. Preferably it should be digital, and integrated into the exposure unit. An analog oven timer is not accurate enough for

shorter exposures such as those required for most water wash polymer materials.

Polymer Cliché Exposures

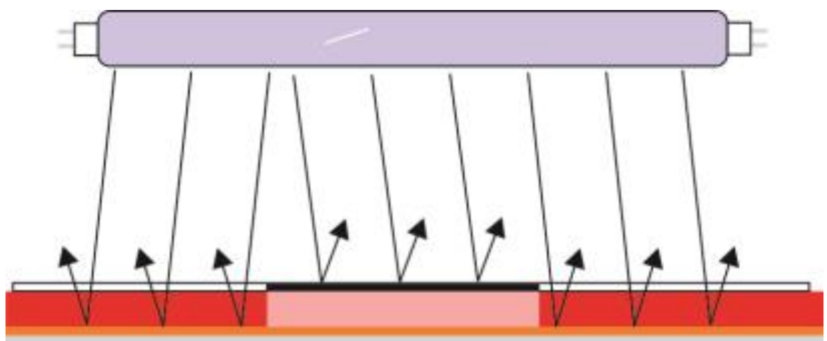


Illustration by John Kaveman

Remember our little illustration of proper film orientation back in the chapter about artwork and film? Here it is again, only this time the light is on, and the U.V. energy is penetrating the polymer layer, all the way down the adhesive layer, and reflecting back out, aligning the molecules polymerize, or hardening, the cliché from the bottom up to the surface, except in the area where the light is absorbed or reflected by the opaque (emulsion) image area, shown in the diagram above as the pink area. This area remains un-hardened.

If we were to develop the cliché after this first exposure with the film, the resulting etch depth (assuming our exposure time was sufficient) would be whatever the polymer layer thickness is. This is what happens with “one-step” or single exposure polymer cliché materials.

For screened clichés, we remove the film with the image on it, replacing it with a line screen film for the second exposure. The line screen film is normally about 90% opaque, with the remaining 10% being clear “dots” that allow the light energy through. As the light passes through the film, it refracts, exposing the previously un-exposed polymer underneath, forming little “dots” or “mountains” as the material polymerizes.

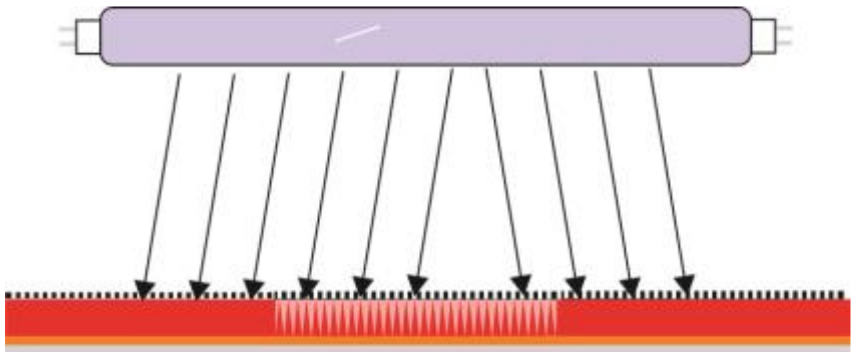


Illustration by John Kaveman

During the development step, the distilled water or alcohol developer is gently agitated, removing the un-exposed polymer from the “valleys” in between the “peaks” formed by the line screen exposure, as shown in the next illustration.

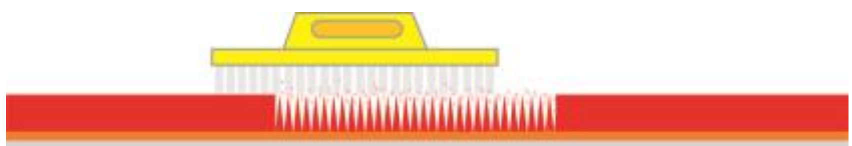


Illustration by John Kaveman

If your exposure equipment and cliché supplier are the same people, they should be able to give you explicit instructions for exposure and development. If they aren't that same people, or they don’t know, you'll need to determine the correct exposure for yourself. Start by asking both parties for their recommendations. They should be able to give you at least a good idea of where to start.

The exposure equipment that I use has multiple 40W with 350 Nm wavelength, and a clear, vinyl vacuum blanket. I know that my exposure equipment makes good, screened clichés when we use the following procedure:

1. Remove the protective film from the cliché surface. Inspect the surface and remove any visible dust or debris. Place the film positive (emulsion down) in the desired location. Gently rub any air bubbles out from between the cliché and the film with the pad of your thumb.

   Hint: If you live in a climate where it gets humid in the summer, sometimes the film will stick to the cliché, causing air bubbles that interfere with good contact. Sometimes it is because the cliché have absorbed some water from the air, and need to be dried before exposure. Other times, you can use a little bit of baby powder on the emulsion side of the film. Baby powder is clear (even though it looks white), and in small quantities won't affect the image. Simple apply a little, and wipe or blow off the excess. This helps keep the film from sticking to the cliché.

2. Place the cliché in the exposure unit and engage vacuum. Ensure that there is a good draw on the vacuum.

   Expose with clear, photographic film. If you are using a laser printed media that is frosted (thus diffusing some percentage of the light energy) you will probably need to expose a little longer than if your film is clear. Same goes for your vacuum blanket. If it is frosted, you may need to expose a little longer than you would if your vacuum blanket is optically clear.

3. Remove the film positive from the cliché, replacing it with the (emulsion down) line screen. Engage vacuum, again ensuring that there is a good drawdown, and make your second exposure. Theoretically, this exposure should be the same length as the first one.

(Skip this step if you are using a material that does not require a screen exposure.)

4. Remove line screen film and place the cliché in the developing bath. Ensure that there is enough developer to completely cover the surface of the cliché. Using a very soft brush or a paint pad, gently agitate the surface the cliché surface. DO NOT SCRUB. Just use the weight of the pad or brush and gently slide if over the surface to remove unexposed material from the image area.

5. Develop with specified developer. Normally, about 2 minutes is required.

   Important: Alcohol wash clichés are developed in denatured, ethyl alcohol. The cliché manufacturers normally specify a denatured alcohol that is 98% pure ethyl alcohol, denatured with 2% kerosene. In most cases, it can be diluted up to about 15% with distilled water.

   If you buy denatured alcohol from the local hardware, paint shop or box store it is most likely diluted with up to 40% water, and may denatured with something other than kerosene. Many times in my career I've received calls and complaints from people who thought that "all of the sudden our clichés just stopped working", and all they did was run out of developer from their pad printing supplier and substituted with cheap stuff from the local hardware.

   The same goes for water wash clichés. Use distilled water, NOT water from the municipal supply, or a well. Those can have additives such as chlorine and fluoride, or may have too high an iron content, etc.

6. Remove cliché from developing bath. Gently dab, but do not wipe, the surface with a soft tissue to remove excess developer. Some people use forced air to blow the developer off the cliché.

7. Place the developed cliché back in exposure unit (without using any film or vacuum) or combination post-exposure unit / dryer, and post expose.

Automatic Developing Equipment

Some pad printing equipment manufacturers have automatic cliché developing equipment. These generally have a lid with a magnetized top where you "stick" your exposed polymer clichés. When you close the lid, the cliché comes into contact with a fuzzy pad (like the surface of the paint pad) or brush, which is submerged in developer, and is agitated (pneumatically) once the cycle is started. They normally operator off of a timer. A TOSH automatic developing tank is shown below.

Automatic Developing Tank.

Photo: TOSH

Post-Exposure of Polymer Clichés

Post exposure of polymer clichés is critical because the bottom of the etched image area and / or the sides of the little "mountains" created by the line screen exposure are not hardened after development. If you skip the post-exposure step, you aren't hardening the etched image area, and your cliché will wear out significantly faster than it would if it was correctly post-exposed.

Drying removes the water or alcohol left over from the developing process. Drying alone should not be considered a replacement for post exposure.

Having a post-exposure unit is handy for drying clichés during humid periods of the year prior to exposure or prior to use on the press (assuming you've stored them for re-use).

The heat generated by the lights during the post exposure may be sufficient to dry to the cliche during post exposure. If very little heat is generated by your exposure equipment, or you make so many clichés that you don't want to use exposure unit time for post exposing, buy a combination post-exposure unit and dryer.

Post exposure unit / dryers have U.V. lights and a heater with a fan that circulates hot air. I use a TOSH post-exposure unit / dryer, with the temperature set to 60^{0}C (140F) for 30 minutes.

Post-Exposure and Dryer Unit.

Photo: TOSH

Quality Inspection of Polymer Clichés

Once your cliché is exposed, developed, post exposed and dried, you can easily do a few things to determine whether or not the cliché is likely good, or bad.

I perform a simple "fingernail" inspection on polymers by holding the cliché up to my ear and gently dragging a fingernail across the surface of the cliché, including the image area. You should be able to hear a faint "zipping" sound as your finger moves across the image area. That is good in that it means your dots are pronounced within the image area. If the cliché is too shallow, you normally won't hear the "zipping" sound.

If the cliché is screened, and you can catch your fingernail on the edge of the image area, it can be an indicator that your cliché is too deep (one or both of your exposures wasn't long enough in duration).

This problem can also occur if, like me, you sometimes (or always) use a laser printable film media that is frosted on the side that comes into contact with the cliché during exposure.

Using a magnifying glass hold the cliché up to a light so that I can view across the surface at a low angle. I am looking for a faint, repeating dot pattern across the non-image area of the cliché.

Normally, a properly exposed and developed polymer cliché will be smooth and shiny in the non-image area. If you can see a dot pattern, it is an indicator that your first exposure (the one with the image film, not the line screen) was too short in duration.

Since polymers harden from the bottom up, too short an exposure can leave the first few microns of the clichés top surface unhardened. When that happens, the second exposure (with the line screen) can expose the line screen not only into the image area (where you want it), but also into the non-image areas of the cliché.

This problem can also occur if, like me, you sometimes (or always) use a laser printable film media that is frosted on the side that comes into contact with the cliché during exposure.

If you've got a line screen exposed into the first few microns of the cliché surface due to a short exposure, you will probably have a hard time getting it to doctor cleanly.

Troubleshooting the Polymer Cliche Making Process

Most of the problems that people experience when making polymer clichés are caused by one or more of the following:

1. Developing solution
2. Cliche material
3. Film density and orientation
4. Line screen film
5. Exposure equipment

Making polymer clichés is like baking a cake. Think of the cliche material, developing solution, film and line screen as the ingredients, and the exposure equipment as the oven. If you have bad ingredients to start with, not even you dog will eat the result of your best efforts. If your oven is too hot, or not hot enough, you'll end up with either a giant hockey puck or a bowl full of really lumpy pudding. The same goes for making clichés. If you have bad developer, expired or "environmentally stressed" cliche material, poor film density, incorrect film orientation, the wrong line screen or a deficient exposure unit your clichés won't turn out any better than your "cake".

Fortunately there exist a series of simple tests that you can perform to help you identify potential causes and remedies in your polymer cliche making process.

Testing the Developer

Depending on your specific type of cliche material you will probably be developing with either water, alcohol, or a mixture of both. More specifically you will be developing with either distilled water or denatured ethyl alcohol diluted with distilled water.

Why distilled water, and not just plain old tap water? Tap water is not the same as distilled water. If your cake recipe called for baking powder, would you add powdered sugar just because it looks that same? Neither would I. Using tap water is a gamble because you never know what is in it. Municipalities add chlorine, fluoride and other chemicals that may not be compatible with the cliche material. Distilled water is much more consistent for developing water wash clichés and for diluting ethyl alcohol for developing alcohol washed clichés.

Alcohol developing solution is best purchased from your cliche material supplier. You can buy a gallon of "denatured alcohol solvent" from the local hardware or building supply superstore, but how do you know what is in the can? Retail stores buy their denatured alcohol from their vendor, who in turn buys it from another vendor or a chemical company. Chances are somewhere along the supply chain, as the chemical is repackaged, it gets diluted with water. The stuff from the hardware store may have left the chemical company 98% pure, but by the time you get it is diluted by perhaps as much as 40%. By contrast, the developer you get from the cliche materials supplier (provided they know what they are doing) should still be undiluted. I can't tell you how many times I have had a customer call after they have been successfully making clichés for years to complain about a "bad batch of clichés", only to find out that they ran out of developer, and in a pinch ran down to the hardware store and bought some stuff off the shelf.

One final word about developer: it works better warm that it does cold. Use water or alcohol that is above room temperature.

To test your developer, develop an unexposed piece of cliche material for the recommended amount of time. If the polymer comes off all the way down to the adhesive layer you developer works. If it doesn't develop it means that either your developer is too weak, or contaminated, or your cliche material is expired.

The polymer of most clichés is clear, or slightly milky looking. The "color" you see when you look at a polymer cliche is really the color of the adhesive layer, not the polymer. You might have to look closely to tell whether you developed or not. If you aren't sure at first glance, dry the cliche and check again.

Testing Cliche Material

Cliché materials have a shelf-life. Most manufacturers will recommend storing clichés in a cool, dry (and U.V. free) place. Prolonged exposure to varying temperatures and periods of extremely high or low relative humidity can damage or "environmentally stress" cliche materials. Clichés are also light sensitive and can easily be exposed by accident, so be sure to work with your clichés under lighting conditions that are free from even ambient U.V. Florescent lights can have U.V. wavelengths, so be sure to shield them, or use an alternative light source for your cliche room.

Cliché materials differ significantly from one manufacturer to another, and between grades with the same manufacturer. (For more information on differences in polymer cliche materials refer to Chapter 13).

Different materials have different exposure times. If you can tell your supplier about your exposure unit (i.e.: number of bulbs, wattage, wavelength, distance from cliche surface, vacuum blanket type) they should be able to give you a well-educated guess as to where to start exposure times.

The test to determine if your material is expired or has been accidentally pre-exposed is the same test used to determine if the developer is good. Develop an un-exposed cliche for the recommended amount of time. If the polymer comes off, it is good.

Testing Film Density and Orientation

Film density and orientation are the most frequent problems for most people. Everyone wants to use a laser printed overhead transparency, vellum, or some other alternative to "real" film. If you can get the laser printed image dense enough the laser film will work fine for most applications.

To test the density of your film expose the cliche with the film only for the recommended time, and then develop it as recommended. After the cliche is reasonably dry, use magnification (a 10X magnifying glass should suffice) to look at the image area. If you can see areas where there are areas within the image that did not develop out, chances are the film was not dense enough in these areas. When the film isn't dense enough a portion of the light gets through and the polymer begins to cross-link (or harden).

The second most common film-related culprit is the orientation of the film. The image has to be on the side of the film that comes in contract with the cliché's surface during exposure. This is commonly referred to as being an "emulsion down film". If you are using a laser printed film media it is easy to determine because you can easily tell which side of the media was printed. With clear, orthochromatic film it can be a bit more difficult to determine, however film is usually shiny on the base side and dull or matte looking on the emulsion side.

If you're not sure about the film, and there is some emulsion or toner in a non-image area, scratch both sides with a sharp edge. The toner or emulsion should scratch off. For future reference some people like to cut the same corner off of their films (for example, the upper right hand corner) so they know which side is the emulsion side and which side isn't.

Having your film orientation wrong will usually result in loss of image resolution during exposure. This will be especially evident in areas with finer line weight.

Line Screen Film

If you're using materials that require a second exposure with a line screen film ask your cliche supplier which lineage they would recommend for your application. For most applications a 120 line / cm (300 line / inch) screen with an 85 - 90% dot is a good choice. If you need to transfer a little more ink you might consider a 100 line / cm (250 line / inch) or even an 80 line / cm (200 line / inch) film.

Regardless of the film you use, the important thing is to get the line screen film on the cliche in the correct orientation. Just like with regular film, the emulsion side of the line screen film must be in contact with the cliché's surface during the exposure. Just like with regular film, line screen will be shiny on the base side and dull or matte on the emulsion side.

Keep your line screens clean with mild soap and water. Also, avoid putting any dents or kinks in the line screen film. If you damage your line screen replace it to avoid having the damaged area interfere with a successful exposure.

Performing Step Tests

Remember the visual inspection described earlier in the chapter? If you perform an inspection and it looks like your exposure was incorrect (too deep or too shallow) you will need to perform a "step test".

If you can see the hint of a screen pattern all over the surface of the cliche (in non-image as well as image areas) you will first need to adjust your first exposure to eliminate that problem. Line screen or dot patterns in non-image areas mean that the first exposure was too short. Polymers cross-link or harden from the bottom up. Underexposure in the first (image) exposure leaves the top few microns of polymer underexposed, allowing the dots in the second (screen) exposure to be exposed on the surface.

To do the step test for the first exposure tape the film down onto the cliche. Use a completely opaque film and make another set of exposures starting with the time you used previously. Every 10 or 15 seconds, move the opaque film an inch or so, allowing that area of the cliche to expose for that additional period of time. Once you've got a cliche exposed with the film using steps, do a screen exposure using the same time you used previously. When finished, develop the cliche and do another visual inspection. The first step where the screen pattern is no longer visible in the non-image areas is your correct film exposure time.

If you're not getting any dots in non-image areas of the cliche but the etch depth is not correct, expose a new cliche using that same image and the correct time, then perform a step test in the line screen exposure. Develop the cliche, and then perform a visual or "thumbnail" inspection. The step where the peaks of the screen pattern appear to be the same height as the surface of the cliche is your correct screen exposure time.

Testing Exposure Equipment

People tend to overlook several equipment related variable, including the power output of the light source, the transparency of the vacuum blanket, and the vacuum pressure.

U.V. bulbs have a life. Depending on the manufacturer the power output of the bulbs drops off significantly at some point, usually somewhere between 400 and 700 hours. If your exposure unit has an integrator that senses the output and automatically adjusts the exposure time to compensate you don't have to worry about it. If you don't have an integrator then keep track of the hours on your bulbs and change them on a regular schedule per the manufacturer's recommendation.

Wattage is another point frequently overlooked. The lower the wattage, the more control you have over the exposure. Most exposure units designed for pad printing use 15 or 20 watt bulbs. Once in a while you will see one that used 40 watt bulbs. Contrary to what you would think, the difference in output between 20 and 40 watt bulbs is not 20 watts, it is the square of the output of 20 watt bulbs. That is why people with 1000 watt metal halide screen printing exposure units have a problem controlling their exposure times. They are exposing, in some cases, for only a few seconds when they should be using a longer, more controlled exposure with a lower wattage instead.

Vacuum blanket materials can also make a difference. For example, if your vacuum blanket is a frosted vinyl it will absorb or diffuse more U.V. light than clear vinyl or glass, so your exposure time will need to be adjusted accordingly to ensure that your clichés are getting the right amount of U.V. If your vacuum blanket has block out or tape all over it, replace it.

Vacuum pressure should be sufficient to eliminate air from becoming trapped between the film or line screen and the cliche surface, as well as between the vacuum blanket and film. Normally when people have sufficient film density yet lose detail, or have varying etch depth, poor vacuum is the cause of the problem.

You can periodically test your exposure equipment by exposing a cliche with a test film (preferably the same one each time), using the same exposure parameters each time. That exposure time should be sufficient to result in the development of the cliche all the way down to the adhesive layer. If at some point, having used the same film and exposure time as usual, your cliche fails to develop all the way down to the adhesive layer it usually means that the output of your light source has deteriorated.

Remember, polymer cliché making is a process, not a craft or an art. Using a systematic approach, you can consistently make good clichés.

13. Doctor Blades and Ink Cups

Doctor blades are a carry-over from the Gravure printing process. In Gravure, the doctor blades are what cleans ink from the surface of the cylindrically shaped plates. Up until the 1980's, most pad printers were "open inkwell", so they used doctor blades to clean their flat clichés. Today open inkwell systems are rare. The exception is rotary pad printing machines, in which case the clichés are drums, and are typically doctored just like Gravure cylinders.

For open systems there are several types of doctor blades: 0.2mm (.008"), 0.5mm (.020") are common. The thin, .02mm (sometimes 0.25mm) flexible doctor blade (sometimes called Gravure blade) works well on finely detailed (small) image areas on any type of cliche. This type of doctor blade is designed to doctor in one direction only. Usually one side that is flat and the other side has a beveled edge. The flat side always needs to go in the doctoring direction.

Thicker doctor blades are usually used only on solid or thin steel clichés. These blades may not be flexible enough for use on polymer clichés. If you're not sure, ask your supplier.

Manufacturers tell you to sharpen, lap or dress doctor blades by several different methods. Some prefer to use a lapping stone, while others simply use 1200 grit sand paper. The best method to use is the one that works for you. Have your supplier demonstrate their recommended method for you first, then try their way. If it doesn't work for you, try another way. The important thing is to end up with a clean, flat edge.

When setting up your machine keep in mind that you only need as much pressure on your doctor blade as is necessary to get it to clean the area you need. Too much pressure is not a good thing. It wears out your doctor blades and clichés prematurely.

Sealed Ink Cups

Sealed ink cups come in every shape and size imaginable. Most, of course, are round. Aside from (mostly) being round, sealed ink cups differ significantly from one manufacturer to another. Some ink cups designs work really well; others, not so much.

Some cups use a one piece machined steel design, others use two, three or four piece designs with solid steel, flexible steel or ceramic doctoring rings.

As is the case with doctor blades in open systems, too much pressure on the doctoring ring in a closed system can damage the cliché. Some manufacturer's cup pressures are easily adjustable, while others are not. Use the least amount necessary to do the job.

Ink Cup Designs

In my opinion, the best ink cup is one that uses magnets to achieve a seal between the doctor ring and the cliche. Also, a multiple piece construction that allows the doctor ring to "float" in relation to the cup body via a seal or "o-ring" will go a long way in compensating for clichés that aren't perfectly flat.

An opening that allows you to add thinner is a must. It is nice to be able to add thinner quickly and without having to remove the ink cup from the machine.

Some type of anti-rotation feature can allow you to make production even if you have a damaged doctor ring. If your doctor ring can be rotated on the cup body, and the cup can be kept from rotating, you can put the damaged area of the doctor ring in the back, away from the direction of doctoring, so that there won't be a fine line of leaked ink through the middle of your image. This will suffice until you can get a replacement ink cup, unless you doctor ring is severely damaged.

Ink cups that are held in the machine by some mechanism that applies pressure nearer the center of gravity (preferably inside center, near the cliche surface) or low along the outside of the cup (at the nine and three o'clock) positions typically doctor better than ink cups that have pressure applied further from the center of gravity (on top, or higher on the sides).

Buyer Beware

There are now companies that manufacture "replacement" ink cups for several brands of machines. These cups are not original equipment, and may void you warranty. If you want your machine to function properly use replacement parts from the machine manufacturer, not from "Part-R-Us".

14. Transfer Pads

Pads have changed significantly since the invention of the process over 100 years ago. Initially inflated animal organs were used as pads. Later gelatins were used in an effort to make pads more durable. It wasn't until the late 1960's that the modern silicone pad was invented in Germany.

Pads are a formulation of a liquid base material, silicone oil, and a catalyst. The base material makes up the mass of the pad. The amount of oil added to the base determines the hardness (or shore), and the catalyst allows the pad to set-up in its mold. The color of the pad can be from either the base material, or the catalyst. Most pads are reddish-brown in color, but there are also blue, white, yellow, green, gray, red and clear pads.

Pads vary in quality depending upon the base material. Cost is usually directly proportional to the quality of material and the volume of the mold. Bases can be made from wood, aluminum, steel or plastic.

Pad manufacturers can have anywhere from a few dozen to a hundred or more "standard" pad molds.   The mold determines the size, shape and texture, and the formulation determines quality, color and hardness of the finished pad.

The Components of a Quality Pad

What constitutes a “good pad”? At first glance the two pads pictured in Figure 1 (below) appear to be of similar quality.

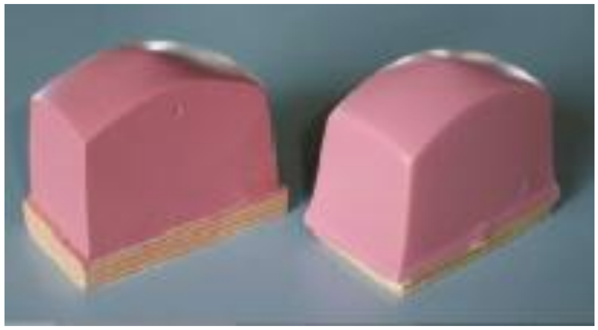


Figure 1

Look again. The vacuum-formed pad on the left was manufacture utilizing a precision master. The pad on the right was manufactured using a vacuum-formed mold of a pad.

Figure 2

The telltale signs that a vacuum-formed mold was made from a pad instead of a precision master are the lack of sharply defined edges and the large taper at the base. Additionally, molds that are vacuum-formed using a pad as a master rarely will produce pads having a consistent height.

In Figure 2, the pad on the right is taller. While this might not present a problem if running this pad alone, it would most likely cause problems if it was used in tandem with the pad on the left because the optimal print strokes would be different. This would be especially troublesome if the pads were individually mounted in an assembly where parallelism is important.

As stated previously, and as Figure 3 illustrates, it is difficult to correctly mount a pad made in a mold that was vacuum-formed using a pad. The pad on the right was mounted crooked. It is approximately four degrees off vertical on the long axis.

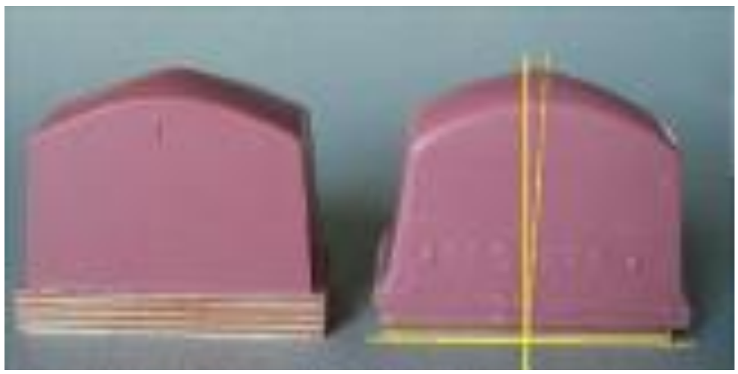


Figure 3

Additionally, in Figure 4 (below) it is mounted crooked in the short axis by approximately four degrees, and as shown in example 5, the wood base was mounted off-center relative to the base of the pad.

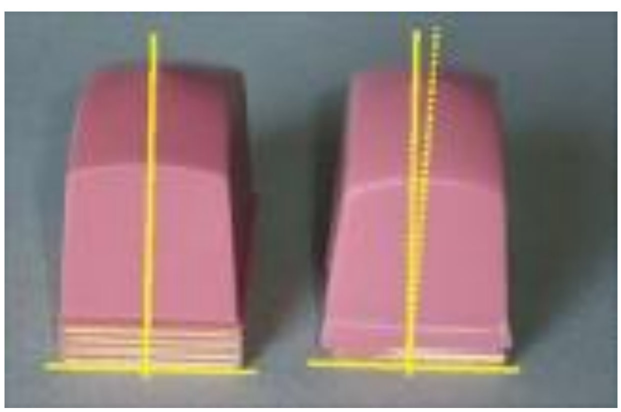


Figure 4

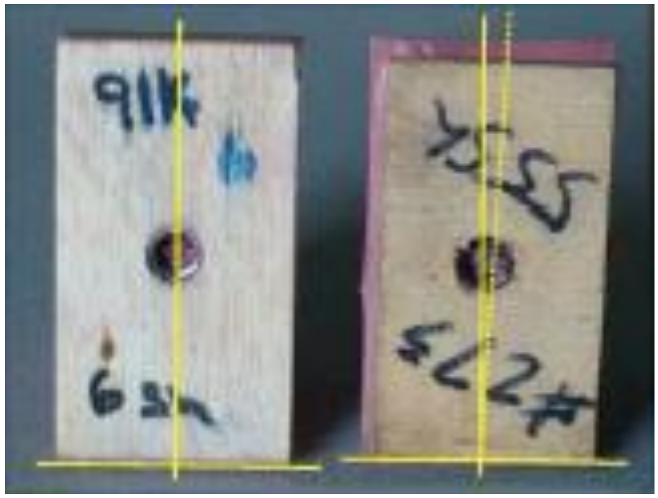


Figure 5

Essentially, the manufacturers of the pad on the right (in Figures 3, 4 and 5) did the following things incorrectly:

1. Used a mold vacuum-formed from a pad rather than a precision machined master.
2. Did not pour the mold to the correct height.
3. Did not mount the pad straight in any of three different axes relative to the base/centerline.

The old saying "you get what you pay for" many times is transposed in pad printing to "you pay for what you get." If the pad in question had been purchased from a discount vendor, you would have paid for it in lost time trying to get it to work.

How Pads are Made

Pad making isn't something that just anyone can do. There are many steps in the process, each of which is as critical as the next.

A properly manufactured mold is CNC machined from aluminum, poured over or vacuum formed from a precision machined "master".

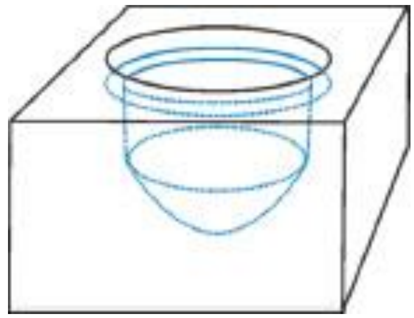
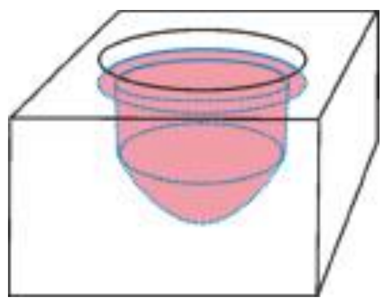


Illustration of a pad mold.

The surface characteristics of the mold will dictate the surface characteristics of the finished pad. For example, a highly polished mold with produce a shiny, smooth pad.

A lip is typically machined into the top edge of the mold to correspond to the dimensions of a precision (laser cut) wood or machined aluminum base.

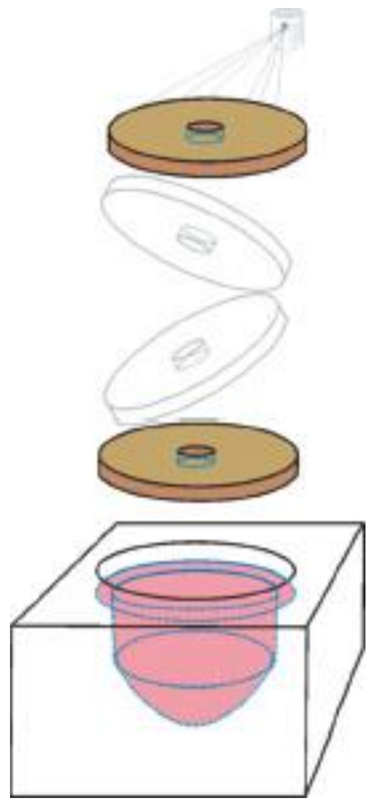


Lip machined in top of mold

Pads are a mixture of three components: base material, catalyst and silicone oil.

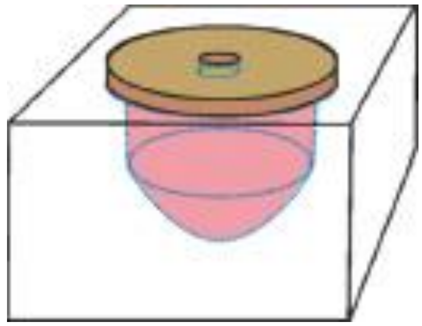
The silicone base material comes in different levels of quality. The higher the material grade the better longevity you can expect from the pad. Most base materials look like Elmer's glue. The catalyst is what gives the pad its color in most cases. Catalysts differ from one another as well, as some cure at room temperature whereas others require heat. The amount of silicone oil in the pad is what determines the shore (hardness) of the pad. The more oil in the formulation, the more pliable the pad and the faster (or more easily) the pad transfers the print to the substrate. Conversely, harder pads require more force to compress, yet transfer with superior image quality. Harder pads also work better for printing on textured surfaces, contrary to what you might expect.

Once the three components have been mixed together they are placed in a bell jar so that all of the air bubbles can be evacuated from the mixture.



Primed base going into the pad mold.

The wood or aluminum bases have to be chemically primed in order for the silicone pad material to adhere. Normally the bases have a hole precision drilled into the center. The hole allows excess silicone material in the mold to escape once the base is clamped on after pouring. Once the pad is cured, the excess material that leaked out is trimmed off, and a threaded insert is installed to allow the end user to affix the pad the machine using a single, threaded screw or pad coupler.



Poured mold with pad base inserted.

Most standard pad shapes are variations of four basic shapes: cone shaped, roof-top shaped, rectangular and square.

Cone

Rooftop

Rectangle

Square

Your supplier should have a standard pad to fit the majority of applications you'll encounter. Most printers have a selection of half a dozen or so pads in varying shore that they use for 80% of their printing. In the event that a standard pad can't do the job a custom pad can be made. Depending upon who your supplier is, having a custom mold built can be a costly and time-consuming process. Some suppliers simply don't want to design, build, pour and store custom molds and pads, while others will do whatever is necessary for you to get the job done. In any event, most people steer clear of custom pads except as a last resort.

Size, shape and hardness are the most important considerations in choosing a pad for any given application. Let's discuss how each of these three variables can affect the final result.

Size Does Matter.

The size of the image to be printed and the size of the machine determine how large a pad you'll want to use. The image, measured diagonally, should not exceed 80% of the length, width or diagonal dimensions of the pad. Anything outside of this recommendation may end up distorted in image pick-up and / or transfer.

The size of machine and cliche are also important. The machine must be able to efficiently compress the pad far enough to pick-up and transfer the entire image. Also, it must be able to do so without interfering with any parts or the cliché holder, the doctoring assembly or ink cup, and without rolling over the edge of the cliché. Also, remember that a pad of the same size, but harder, will require more energy to compress. The same must be considered when choosing pads for multiple color machines.

"Ink-less Compression Test"

You can do a quick test to determine if your compression is sufficient without ink, using only the pad(s) and any cliché. Follow these steps:

1. Put your pad(s) in the machine.
2. Put a thin layer of light oil on the image area of the cliché.
3. Place paper where your image will print. (Preferably over the actual part that will actually be printed.)
4. Cycle the machine once, allowing it to pick up the oil and transfer it to the paper.
5. Measure the area(s) that the pad(s) picked up and printed to see if they are sufficient. If not, adjust compression setting(s) as necessary, and try again.

If you can't pick up and transfer a large enough area then you'll have to use a smaller or softer pad(s), reduce the size of your image(s), or use a bigger machine.

Shape

The shape of the part is the main factor in determining the shape of the pad. The pad should have a rolling action as it is compressed over the surface of the cliché and the part. The roll starts at the point (or ridge) and travels outward, pushing the air out of the way as it goes. In theory you want to be able to pick up and transfer the image without ever creating a zero degree angle between the pad and the surface it is being compressed onto.

Translated that means that you want a pad steep enough so that it will compress far enough to pick up and print the entire image without trapping air. Basically, the steeper the angle and the greater the mass of the pad, the better. This is especially evident when printing textures.

Compression plays an important role. Too much compression and you can reach a zero degree angle no matter what the angle of the pad. A fundamental rule to remember in setting pad compression on both the cliché and the part is this:

Use the minimum amount of stoke necessary to pick up and transfer the image.

Too much compression traps air between the surface of the pad and the cliche or ink, resulting in the print having voids. Too much compression also produces undue wear on the pad, and the machine.

Location, Location, Location.

The location of the image on the pad is very important. In compression the point may trap air. For this reason, it is recommended that you avoid placing the point of the pad directly in the image unless you absolutely have to. Move the point far enough away from the image so that it won't create a problem when compressed. If you can't change the location of the pad due to some mechanical limitation, change the location of the image on the cliché.

Cone-Shaped Pads

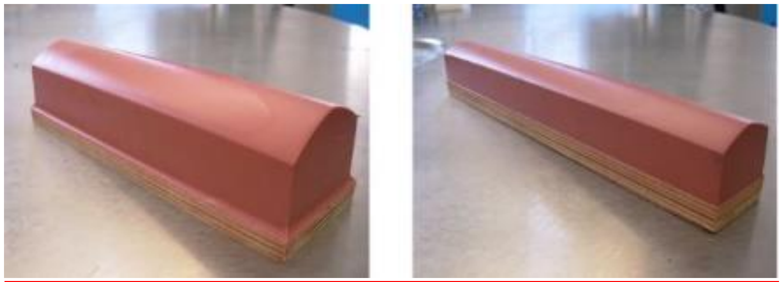



Cone shaped pads are, perhaps, the most versatile for printing on a wide variety of shapes. Rolling at the same angle 360 degrees from their tip, cone shaped pads offer excellent consistency when printing flat and / or textured surfaces. Cone shaped pads are often used to print on spherical objects.

In some applications it is necessary to hollow out the inside of cone shaped pads to allow them to be compressed further around a sphere. One example is the balls you see in toys stores printed with cartoon characters. By using a special cone pad which is inflated during image pick-up and deflated during image transfer, the image can be wrapped 180 degrees on the ball.

Another variation of basic cone shape is the "dough-nut" pad. Used to print things like oven knobs, these pads have relieved tips that allow the pad to compress without interference from the raised areas of the knob. The illustration below shows two commonly shaped cone pads, and two "doughnut" pads.

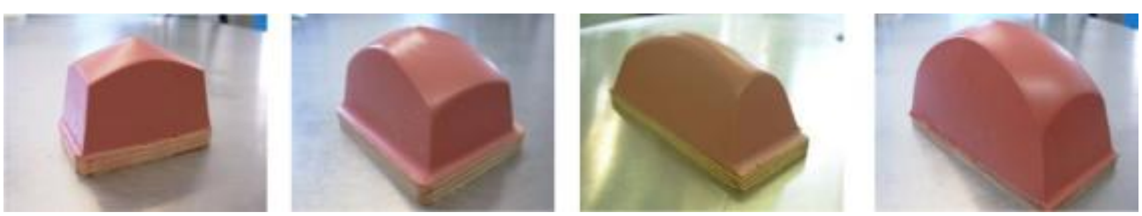
"Roof-Top" Shaped Pads



Roof-top shaped pads are especially useful for printing images on flat surfaces in cases where the image has straight lines, or blocks of text. Roof-top pads compress in opposite directions from their center ridge. Placing the ridge between lines or blocks of text allows the image to be transferred without trapping air. Roof-top pads are also very useful for rolling images from a flat surface up or down onto an angled surface. (I've found that it is easier to roll an image up than down, since it requires less compression.)

Roof-top pads aren't limited to being straight down the center. The ridge can be off center, allowing the pad to compress at different angles on each side when necessary.

Rectangular Shaped Pads

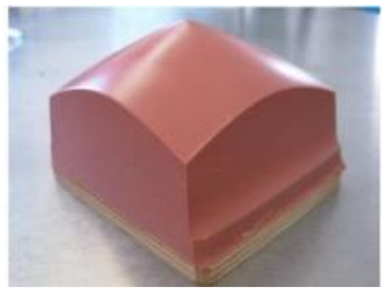


Rectangular shaped pads usually have a higher angle of compression along their short axis. These pads work well for printing oblong images that cannot be printed with cone shaped pads, and for printing on a radius.

Hollow rectangular pads are useful for applications where you need to be able to compress a long way to pick up a wide image with a machine that can't compress a solid pad having the same surface area. Hollow rectangular pads are also commonly used to print on a radius.

Rectangular pads don't always have two tapers. Sometimes their angle is a single radius. These pads are useful for printing on a radius, but are difficult to use on flat surfaces since they tend to trap air easily.

Square Pads



Square pads can be used for many of the same applications as cone and rectangular pads. They're useful when a radial compression pattern won't work because of distortion, and when the image doesn't require the long, low angle of a rectangular pad. Most square pads are solid, since compressing a hollowed out square pad usually results in the image distorting inward towards its center.

Positive and Negative Draft

Very few pads have sides that are 90 degrees to their base or printing surface. Most standard pads have what is referred to as a "positive draft". That means that they are wider at their base with the side walls angled in toward the printing surface. When pads having a positive draft are compressed the side walls bulge outward, which is fine for most applications. When printing down into a recessed area (or next to a perpendicular plane) a pad having a negative draft is sometimes necessary. With negative draft a pad can be compressed without its side walls interfering with the walls of the recess.

Rotary Pads

Rotary pads are normally completely round, solid pads. In cases where polymer clichés are used, they are notched to avoid compressing on the clamps that hold the cliché on the drum. Finally, they can be a series of individual pads simply mounted to a drum.

Shore

Hardness is the last of the three main considerations in choosing a pad. Hardness is also referred to as "Shore" or "Durometer", which for lack of a better definition are types of scales used for quantifying hardness.

A pad's hardness comes into play for three main reasons. Two pads of the exact same shape having different hardness will require different amounts of energy to compress the same distance. So hardness is a consideration in choosing size.

Second, the composition of the pad is important in considering hardness. A hard pad would crush a fragile part like a light bulb.

Third, the texture of the surface you're printing on is very important. Hard pads do a better job of printing textures than soft pads. To most people this comes as a surprise, but it is true.

Soft pads tend to transfer the ink to the peaks of a texture without getting into the valleys. When this happens, air is sometimes trapped in the valleys, later escaping to create pinholes. Plus, since the ink suspended between the peaks isn't sticking to anything, it is less resistant to abrasion. Hard pads get further down into the texture before they transfer the ink.

Printing Textured Surfaces

Some textures can't be filled regardless of how hard and / or steep a pad you use. Many textures are simply too deep, or have too fine a grain to be covered even if you print several times over. In most cases if you get pinholes on the first print you can't fill the pinhole in on successive passes.

Unfortunately, most plastic injection mold designers have no knowledge of this phenomenon, and they continue to specify difficult textures. As a result, we pad printers get stuck trying to print it later on. To use an analogy, it is like trying to paint a cinderblock wall with a roller.

The alternatives are limited. One option is educating the molder, who in turn can educate his mold makers and designers. Getting a mold changed after the fact usually isn't an option, and de-bossing the print area isn't usually cosmetically pleasing in the end result. If the print has to be absolutely pinhole free about the only thing you can do is bridge the texture intentionally.

You can sometimes bridge with multiple passes by adding air blowers. Directing the air at the part dries the ink between passes, which can increase transfer efficiency. Tacking the ink off a bit more once it is on the pad by adding air there, or by slowing the machine down can also help. Consistently bridging any texture is difficult for even a skilled technician.

There are numerous "standard" textures used in the injection molding industry. Some automotive and electronics companies have proprietary textures. In an effort to find a correlation between texture size and depth and print-ability I contacted Mold-Tech, an internationally recognized leader in mold texturing, and obtained a visual texture standards book containing 68 molded plaques made of black ABS material. Using a steel cliché with an etch depth of .001", a hard conical pad, and a two component ink recommended for ABS, I single and double printed each plaque with a moderate cycle time. (5.5 second single, 11.0 second double print.) I found that the depth of the texture didn't matter as much as the size and frequency (or number) of peaks and depressions within a given surface area. Textures with a depth of up to .0055" were easily printable, provided that they featured large enough "pores". Contact me (the author) via e-mail at padprintpro@gmail.com for a copy of the table showing the results of my MoldTech printing test.

The safest approach for the pad printer is to obtain samples of the texture prior to agreeing to run production, then test printing them to determine if the desired print quality is obtainable

Pad Color and Texture

The color of the pad is rarely an issue. Different silicone manufacturers use different colors to denote quality. I recommend buying pads made from the highest quality material your supplier has in order to get the best performance possible, regardless of what color it is. If color is important to you shop around to find the supplier with the best quality material in the color you want.

Pad textures vary depending upon how smooth the mold that was used to make it is. In most cases differences in the texture of the pad don't adversely affect the print. However, there are those people who prefer the smoothest possible finish for printing on things like the windows on cellular phones, where an inconsistent ink film thickness of the smallest degree becomes noticeable. Others feel that a fine texture on the surface of the pad helps keep the pad from sliding when printing slippery substrates.

Pad Swell

Exposure to most conventional solvent based inks will cause the image area on the surface of the pad to swell a few thousandths within a first 100 impressions or so. This swelling can be beneficial since it allows the pad to pick up more ink from the etched area of the cliché. In order to capitalize on the benefits of pad swelling, many technicians will print a piece of scrap or paper until their pad swells prior to printing their first production part.

Another useful trick is to place the pad in the machine and position it where you want it for production. Set the compression to the correct amount for pick up, then cycle the pad up and down in location for several minutes in a little puddle of thinner. This will help swell the pad in.

Pad Life

Pad life is a common concern. The life of any given pad depends on its initial quality, the aggressiveness of the inks and solvents, the amount of compression it receives, the type of etch the cliché has, the material you're printing on and how well it is taken care of. Some pads wear out in 200 impressions, others last hundreds of thousands of impressions. There is no magic number, only recommendations:

1. Pads should be stored on their base away from direct sunlight and excessive heat or cold.
2. Pads should never be stacked on top of one another. Stacking can cause flat spots in the pad.
3 Keep pads clean. Don't store a pad with ink left on the surface. Avoid cleaning pads with solvents. Use de-natured alcohol instead. Clear packaging tape is also great for cleaning pads. The tape will remove ink and debris without removing the silicone oils.

New Pads

New pads usually have silicone oil on the surface. The amount of oil will depend on the pad's shore. This excess silicone oil can inhibit the pad's ability to pick up the image from the cliché and may result in uneven image transfer. To remove this excess oil from the surface of the pad wipe it with a clean rag, dampened with a relatively fast solvent such as acetone. This should only be done with new pads.

Another useful trick (mentioned previously) is to place the pad in the machine and position it where you want it for production. Set the compression to the correct amount for pick up, then cycle the pad up and down in location for several minutes in a little puddle of thinner. This will help swell the pad in.

Pad Oil

Some manufacturers sell silicone oil for rejuvenating old, dried out pads, and for protecting pads that are stored for long periods between uses. This oil can be kneaded into the surface of pads once they have lost their transfer properties, or on a regularly scheduled basis as maintenance. Pad oil is marginally effective once a pad has been dried or worn out, and then only for a limited period of time. If the pad is depleted of silicone oil the best thing to do is replace it, rather than waste time and money trying to put silicone oil back into the pad from the outside.

15. Pad Printing Inks and Additives

Standard pad printing inks are made up of ***resins*, *pigments*** and ***thinners*.**

The ***resin*** system, sometimes referred to as the binder, is what forms the dried ink film. There are numerous resin systems including epoxy, enamel, vinyl, acrylic and polyurethane.

Pigments are the colorants that are dispersed in the resin system. Inks used for process applications must be transparent. These inks may get their color from dyes instead of pigments.

Thinners adjust the viscosity of the resin / pigment mixture, and give the ink its printing characteristics.

Additives

Catalysts, retarders, adhesion modifiers, **matte** and **gloss agents**, and **anti-static agents** can also be added to ink for the following reasons:

Catalyst (or *hardener*) is sometimes added to ink to increase the inks abrasion, chemical and light resistance, and in some cases to increase adhesion. Catalysts react chemically with the resins to polymerize the ink film. Hardeners can also help increase an inks gloss level.

Retarders are sometimes added to ink to slow their drying time. Retarders are really just very slowly evaporating thinners. Retarders can be liquid or paste in form. Liquid retarders are typically blended with thinner, as by themselves they usually slow the drying of the ink down too much, requiring you to run very slow cycle times or use a lot of air blowers to achieve transfer.

Paste retarders are useful, especially for very fine detail or process color pad printing, as they slow the drying of the ink without changing the viscosity of the ink. They allow you to print small detail or process color separations without “gaining” line widths or dot sizes during transfer.

Adhesion modifiers are sometimes added to ink to increase their adhesion to certain substrates.

Matting agents are sometimes added to lower the gloss level of inks. Matting agents are also used in clear resin to create a frosted varnish.

Anti-static agents can be added to reduce the ink's capacity to produce a static charge. These agents change the surface tension of the ink. If you add anti-stat to ink used in applications where multiple inks overprint, every ink which prints in succession may also have to have anti-stat added to avoid inter-coat adhesion problems.

Flow agents such as thixotropic paste can be added to the ink to help the ink maintain proper flow in process printing, and in some cases when printing in conditions of high humidity.

Pad Printing versus Screen Printing Inks

Pad printing inks are similar to screen printing inks, but there are differences. Pad printing requires that the solvents "flash off" quickly, allowing the ink to tack so that it can be picked up and transferred by the pad. Screen printing inks have solvents designed to keep them wet so that they don't dry in the screen. As a result, most screen printing inks that are packaged "ready to print" are usually too slow for use in pad printing machines.

Another difference is found in the pigmentation. Pad printing inks have a higher percentage of pigment than screen printing inks, allowing them to compensate for the fact that pad printing deposits less ink than screen printing. The size of the pigments also differs in that the pigments in pad printing ink are smaller.

Types of Pad Printing Ink

There are several types of pad printing ink available. Standard solvent based inks are the most common and come in two basic varieties: one component and two components.

One component inks are those inks which do not always require the addition of a catalyst. (Some standard inks can be used with or without a catalyst.) These inks are also referred to as being "solvent evaporating" inks.

Two component inks, also referred to as "reactive inks", must have a catalyst added. When working with two component inks the catalyst is usually added at a specific ratio by weight. It is very important that the manufacturer's recommended ratios be carefully observed when working with these inks. Adding too much or too little catalyst can significantly affect the performance and pot life of the ink. (Pot life is the time period during which component inks are useable.) Also, because two component inks typically react chemically with the thinner to cure, it is recommended that you add the catalyst to the ink in the proper percentage and mix it well prior to adding thinner. Adding thinner directly to catalyst can significantly affect performance.

Drying and Curing Solvent Based Inks

Standard solvent based inks dry by evaporation of their solvents. The chemical reaction between the catalyst and the ink in two component ink takes place independent of solvent evaporation to cure the ink by polymerization.

Drying and Curing are NOT the same thing.

Drying and curing are not the same thing. Most ink manufacturers specify recommended times and temperatures for drying and curing separately. Drying means that the ink film is dried to the point where it is not tacky to the touch. Most standard inks dry within a few minutes at room temperature.

Cured means the ink has reached its highest level of adhesion and hardness. Curing can take anywhere from minutes to several days to occur. Testing ink for performance on any substrate should not be conducted until the curing schedule has been completed. This can take anywhere from 24 hours to 5 days (or more). I typically wait 72 after printing before I test inks for adhesion and chemical / mechanical resistance.

When dealing with two component inks it is especially important to observe the recommended temperatures for curing. Printing parts with certain two-component inks and then storing them at temperatures below 45 degrees Fahrenheit can stop the chemical reaction. Once stopped, it cannot be re-started, and the ink never fully cures.

Baking Inks

Baking inks are common for use in printing on glass and ceramics. These ink are usually two-component, solvent based inks which require a special hardener and sometimes a special thinner. They must be baked in order to cure.

Oxidizing Inks

Oxidizing inks absorb oxygen from the surrounding atmosphere to polymerize without a catalyst. These inks are usually used where weather and chemical resistance are necessary in addition to flexibility. These inks have limited use due to their slow drying times.

U.V. Curable Inks

I've only recently (within the past year) become a proponent of UV inks for pad printing, largely because in order to pad print UV ink you need to add thinner - something that UV inks, but nature, don't need. I've also found a lot of UV inks aren’t opaque enough to cover the substrate with the pad printing process, and / or that they require hardener, which seemed counter-intuitive to me. Most people are attracted to UV because you don't need to add hardener (so you don't have a pot life to deal with).

The biggest limitation of UV inks is that you need to cure each individual hit (or transfer) before over-printing or printing in close proximity, where the pad for subsequent transfers is going to touch otherwise uncured ink. For this reason, UV inks are pretty much limited to one color applications, or multiple colored applications where the size of the part and printing system can accommodate curing in between (such as a small part that can go on an automated rotary dial with small curing units in between each printing location on the dial).

Recently, however, I was tasked with solving some interesting adhesion problems with a particular UV ink on a glass filled polypropylene substrate. I found the ink to have excellent transfer efficiency and great durability once it was properly cured and a properly pretreated substrate.

In another application I printed UV curable inks onto powder coated parts. We printed a variety are different colored parts, all with white ink. I was shocked during development when the UV ink that I was using provided faster transfer speeds as well as superior opacity, even versus “old school” two component inks like the venerable Type B with BH hardener. The ink I was using: Marabu TPC. It was amazing and has since become my “go-to” UV ink for pad printing.

I did find that UV inks seem to need a higher substrate surface energy than most conventional solvent based inks, probably because the higher percentage of thinner (by weight) in solvent based inks enables them to “bite in” to many substrates better than UV.

So, if you're thinking about pad printing UV ink, remember, you need to be able to:

1. Cost effectively cure each color before applying the next.

2. Put enough UV energy to the ink film to complete the cure.

3. Have sufficient surface energy on your substrate.

4. Be careful not to overload the ink with too much solvent; be sure to control your I.R. temp and dwell to drive the solvent out.

5. Be sure to add hardener at the correct ratio.

6. Be sure to have the correct etch depth/line screen in your cliché.

Other Printable Inks and Materials

There are a few other inks that people transfer with pad printers. Edible inks, silicone inks and water-based inks are a few examples. Since these ink lack evaporative solvents they are difficult to use in this process.

In addition to inks, lubricants, resists, conductive materials and adhesives are pad transferred in some manufacturing processes.

Selecting an Ink

All ink manufacturers and distributors provide technical information that recommend which substrates an ink *may* adhere to, as well as what catalysts and thinners to use. I say "recommend which substrates an ink may adhere to" because not all inks will stick when used as recommended, all of the time.

In order to select an ink you need to know exactly what you're substrate is, and rather or not pre-treatment of the substrate is required. You also need to know what properties like color, adhesion, abrasion, chemical and weather resistance, and drying times the ink must have. You may need to know if there are any special requirements with regard to the ink's toxicity. Let's review these considerations in detail.

Substrates

When the guy at the pad printing company asks the inevitable question, "What is the material you are printing on?" Please, don't respond, "Plastic." And when he asks, "What type of plastic?" Please don't say, "Black plastic." Try to find out exactly what you're printing on. If you're printing on plastic, get the trade name or chemical name. If you're printing on painted surfaces, find out what kind of paint it is. If the product is plated, know what kind of plating it is. The more you know about the exact composition of the material you're trying to print on the better off you'll be.

Issues Pad Printing Thermoplastic Elastomer (TPE) / Polyolefin (TPO) / Polyurethane (TPU)

TPE, TPO and TPU materials can present some significant challenges when it comes to decorating. Their soft, flexible tactile qualities make these materials popular for over-molding of “soft touch” coatings on control knobs, handle and levers as well as for items such as smart-phone sleeves and covers.

Unfortunately, these materials are very difficult to adhere to, and don’t provide a stable enough substrate for most inks and coatings.

Adhesion has largely to do with surface energy. When you measure the surface energy of these materials they are frequently below the 38 Dyne / cm^2 that we generally reference as the “minimum” for pad printing. Even if they’re pretreated using corona / plasma / batch plasma to increase the surface energy to within an acceptable range for printing, plasticizers that are part of the material’s chemical makeup frequently leech out toward the surface over time, causing printed images to essentially “float off” from the surface within a short period of time (weeks or month, maximum).

In one application I tested over 40 combinations of different pre-treatments, pad printing inks (with various resin systems), adhesion modifiers, and post-treatment… all without success. This was in an effort to print the eyeballs in two colors on a green frog molded from TPU, which was designed to fit over the pump handle for soft-soap dispensers.

Even in those rare instances where you can get adhesion, the soft, flexible tactile qualities that make these materials attractive to designers detract from the printed image having any mechanical resistance. If you can scratch the surface of the molded material with a fingernail, printing on it won't make it any more durable, so even moderate abrasion will rub the printing right off with any material that it managed to adhere to initially.

The best thing that designers can do when over-molding with TPE and similar materials is to leave an area for printing on the base material, which on rigid products is usually a styrene or styrene blend.

As a decorator it is incumbent upon you to insist on the test printing of physical samples of these materials prior to production.

Color

Color is probably the single most misunderstood property of pad printing inks. Most people incorrectly assume ink will appear to be the same color regardless of what color the substrate is. Take bright colors like white, yellow, orange or pink for example. These colors may not appear correct when printed on dark colored substrates regardless of whether you print once, twice or three times. In many cases bright colors must be under printed with white first. This is also a consideration when you're printing multiple colors of ink on top of one another. Why? It is a consideration because pad printing doesn't lay down very much ink. The dried ink film resulting from a single print is usually only 20 to 40% of your etch depth. At that thickness, even with millions of tiny pigments, the ink rarely absorbs or reflects at total of 100% of the light (color), so you end up seeing the effects of the substrates color. For example, the yellow you printed on the white substrate looks green when you print it on a blue substrate. (Blue and yellow make green). As a result, if you are printing a "proprietary" color on a series of significantly different colored substrates you might need more than one color match or color recipe.

How do you know for certain if the color is going to appear correct on substrates of different colors?

A. Hold the stir stick up next to the color chip and compare.

B. Wipe some on the substrate with the stir stick.

C. Measure it with the spectrophotometer (if you have one).

D. None of the above.

The correct answer is D, None of the above. The only way to know for certain if the color is going to appear correct on substrates of different colors is to print the same color on all of the various substrates, being careful to eliminate as many variables as possible by using the same cliche, pad, thinner : ink ratio and machine settings.

All too often color matches are taken for granted until timing is critical. Avoid placing yourself between a rock and a hard place at the last minute by requesting color samples and, if applicable, tolerances from your customer early on in the project. It will probably take weeks for them to understand what you are talking about, and another week to get it to you.

In a perfect world, all color samples would be created by pad printing on a substrate having the same color, gloss and texture as the product you're trying to print. This would ensure that variables resulting from differences in substrates (i.e. color, gloss, texture) and colorants (pigment size, spacing and ink film thickness) are eliminated. Unfortunately this is rarely the case. More often than not it is required that colors be matched by means of a color matching system like the Pantone Matching System (P.M.S.), or to a plaque which was screen printed, powder coated, or painted. In some cases the pad printing process is simply not capable of matching a color to meet a customer's specification.

Most ink manufacturers offer color matching systems capable of matching most P.M.S. colors close enough for acceptance by the human eye. It is where color measuring instruments like spectrophotometers and colorimeters are used for final acceptance that problems arise. All you can do is obtain samples and match them as closely as possible, then get your customer to agree to your match before it's too late.

Spectrophotometers and colorimeters are intended to be tools to aid in obtaining a visually acceptable color match, not a test method for determining whether a part passes or fails for color. Avoid the pitfalls and expenses of trying to make a computer subjective. Computers are objective, and they can be fooled. I have seen good "computer accepted" color matches that were nowhere near visually acceptable. In the end people will be looking at the parts, not computers.

Color booths are also helpful in evaluating color. Color booths come with three, four or more light sources, and are painted a neutral color on the inside. You can evaluate the color using CWF or cool white florescent, like the overhead lights in most offices, D65 or daylight 65 which is supposed to represent sunlight, U.V. which uses U.V. wavelengths in addition to wavelengths we can see, and others. This can be important for really specific color matching because a color that appears correct under one source may not appear correct under another. If you know the conditions under which the final assembly will be viewed by the customer or end user you can then recreate it in your color lab.

Another useful tool for color matching and mixing is a programmable scale. TOSH has a couple of color matching systems with corrective scales. These scales use a stored recipe, or communicate with a PC that has the recipes stored on it. When the person mixing a batch of ink adds a little too much of a given colorant the scale and / or PC tells the person how much of the previously added colors to add in order to correct the batch.

Four color process printing with cyan, magenta, yellow and black (C.M.Y.K.) must always be done on a white background. (These inks may be called transparent blue, transparent red, and transparent yellow.) In four-color process light must travel through the ink to the white substrate and reflect back to the eye, so the inks must be transparent. If you have to print four color process on a substrate that is any color other than white you might as well figure on having to print five colors, starting with white first.

Florescent colors are also limited as to the colors that they can be printed on and still appear florescent. In most cases they will require a white under print just like four color process.

Adhesion

99% of the time no property ink can have is more important than adhesion. After all, what difference does color, abrasion and chemical resistance and drying time make if the ink doesn't stay on the product?

As I mentioned, all manufacturers have technical information about which substrates ink may adhere to. Once you know exactly what your substrate is the technical information available from most manufacturers can usually give you a few probable inks. Ink and equipment manufacturers and distributors usually have applications labs that will test print your parts to determine which ink is best suited to your application, or recommend which inks you can obtain samples of for testing on your own. Test printing is usually free, although a nominal charge may be applied to cover the cost of making clichés if you insist upon having a specific image printed. Even then, these charges are usually applied toward purchases. Results should include information on anything that was added to the ink, (i.e. hardener, thinner, adhesion modifier, etc.) the exact percentages that were added, and curing requirements.

Test Prints

If the ink supplier you contact offers to test print your parts for you instead of sending you a sample, take them up on their offer. Free samples cost money not only for the ink supplier that has to pour them off into special containers and ship them, but for you as well because you still have to spend your valuable time conducting the tests in your facility. Let the ink supplier figure it out so you don't have to. It's their job. If all they want to do it throw a sample in a box and expect you to figure it out find another supplier, preferably one that wants to sell you a solution and not just a can of ink.

Just to be safe you may want to verify the results of any tests conducted by a lab prior to beginning production so as to make sure nothing got lost in communication.

If you have a substrate that is particularly soft and pliable, like an elastomer, be advised that it may be very difficult to get an ink to adhere. In many cases elastomers contain plasticizers (agents that give them their flexibility) that leech out toward the surface over the course of time. In many cases I have seen an ink adhere initially, only to flake off several days or weeks later. Many of these materials are so soft that you can scuff them with a fingernail. If that is the case it is important to recognize that the printed image is only as durable as the substrate it is printed on. Printing it won't make it any more durable.

Abrasion, Chemical and Weather Resistance

Resistance to abrasion, chemicals and weathering are important considerations when choosing ink for most applications. Nearly everyone needs some degree of abrasion resistance. Some ink can be very abrasion, chemical and weather resistant when used as single component systems, while others require the addition of catalysts.

Catalyst not only make two component inks harder and thus more resistant, but they can also increase adhesion and gloss. Some inks have "U.V. resistant" catalysts specifically formulated to increase fade resistance for outdoor applications. Others may have separate catalyst depending upon how they are to be cured (i.e. forced air versus kiln dried, etc.).

Technical information should indicate the ratio for mixing ink with catalyst. Some inks have specific ratios (i.e. 4:1, 10:1, etc.) that <u>must</u> be strictly adhered to, while others have an acceptable range at within which you can add more or less, depending upon the application (i.e. 10-20%, etc.). Since colors don't weigh the same, most ink manufacturers specify ratio or percentage by weight, not volume, so a scale is necessary. If possible, use a scale capable of measuring to within at least a tenth of a gram. A digital scale is faster and easier to use than a balance scale.

Generally, the higher the ratio or percentage of catalyst, the harder the ink will be after it cures. Since most catalysts add gloss, the higher the ratio the glossier the ink. Finally, the higher the ratio the shorter the pot life. I say generally, not always. Check with your ink manufacturer.

The two components <u>must</u> be carefully weighed and *thoroughly mixed* together *before* any thinner is added. Adding thinner directly to catalyst can cause "solvent shock", which can reduce pot life, adhesion and print-ability.

Curing Time

Curing time becomes an issue in industrial applications where newly printed parts receive successive operations such as assembly. In recent years the onset of "just-in-time" manufacturing in the electronics and automotive industries has resulted in many parts being assembled within minutes of being printed. Since all two-component and yes, even UV curable inks are at least somewhat “post-curing”, you can’t ignore the fact the assembling, packaging or shipping parts before the ink is completely cured will inevitably cause a problem.

Not a week goes by when someone asks, “What can we do to speed up the curing of our [two component] ink?” The answer is: Not much.

The catalyst in pad printing are usually diisocyanates, which actually react with the water vapor in the air to cure. Factually, printing and curing in an environment with higher relative humidity will shorten both the pot life of the ink and the required curing time. That's great to know, but hard to do in production, since high humidity causes a lot of ink transfer issues. Unless you can print in an ideal environment (70-72^0 F, 50-55% RH) and then cure somewhere hot and damp, you'll just have to suck it up and wait until your parts cure under ambient conditions.

If you even suspect curing times may be an issue with your process it is important that you relay that fact to your supplier's technical people. They may be able to help you avoid having to sacrifice abrasion resistance to meet your schedule by recommending special additives or curing methods. Obviously knowing the limits of any drying / curing equipment at your disposal will aid you in choosing an ink with an acceptable cure schedule. Don't over-commit on turn around times unless you're prepared to print a job twice.

Toxicity

These days there are a host of environment and toxicity considerations when printing just about anything. Some states (California) have some nearly impossible-to-observe regulations for "hazardous ingredients" (California actually lists aspirin as being hazardous). Then there are REACH regulations and more.

It's a fact that certain products require that inks used in printing be non-toxic. Children's toys, medical supplies and instruments, and food containers are just a few examples. Many ink manufacturers have non-toxic formulations. Non-toxic generally refers to the dried ink film and does not include the solvents used. Be sure to let your supplier's technical people know about any special requirements you must meet with regard to the ink's toxicity.

Smell is normally the main thing people complain about. To avoid this as much as possible, I recommend placing your ink mixing / make-ready and clean up processes outside of the general work area. To be safe, put it in a separate room with negative pressure so that all of the vapors associated with ink mixing and cleanup are evacuated / exhausted away from operators.

Having said that, I've been in numerous situations where the plant safety officer showed up with a vapor monitor and tested to see whether operators were being exposed to vapors in quantities that were harmful, and I have yet to experience any issues. Any time someone is exposed to a new odor it "smells". If it isn't harmful (test to be sure), they'll get used to it. If the vapors are at a harmful level, then be sure to take measures to adequately ventilate the work environment.

Local, state and federal agencies may also regulate certain inks due to their contents and emission of V.O.C. (Volatile Organic Compounds). Be sure you receive Material Safety Data Sheets (M.S.D.S.) with your inks, thinners and additives, and maintain them as required. Suppliers shouldn't ship you anything without an M.S.D.S.

Performance Certification

The big thrust toward ISO 9000 Certification and its equivalents has a lot of people calling their suppliers requesting documentation that their ink meets specific color and / or performance specifications.

The issue of certification is murky at best. In most cases an ink manufacturer will not certify that their ink meets a performance specification unless they have tested their ink at *your cost* after it was applied *by you*, on *your product*, in *your facility,* using *your process.* Who can blame them? After all, the manufacturer or supplier has no control over the ink once it leaves their facility. They can't guarantee your parts don't have a mold release agent on them that will impair adhesion. They can't guarantee your technicians stirred the ink, added the catalyst and thinned it as recommended. They can't guarantee you cured the ink as recommended.

Some automotive and electronics companies have approved source lists that show which ink manufacturers inks have been tested and approved per their specifications. Even in this case it usually states that utilizing a product (ink) from an approved sub-supplier (the ink manufacturer) does not relieve the direct supplier (the printer) of responsibility for the quality of that product.

What some companies that print or buy printed products have chosen to do is attempt to make their ink suppliers pay for the tests on a *"do it or we'll find another supplier"* basis, thus relieving themselves of the cost and responsibility for doing so. This is where much of the confusion has come into play, since there are hundreds if not thousands of different performance specifications out there, and no ink manufacturer or distributor can realistically afford to pay for the necessary testing to certify to all of them. If the ink manufacturers did pay for all the testing the ink would be significantly higher in price.

Most manufacturers will certify the continuity of their product from batch to batch, since they control their own manufacturing process. This certificate of continuity, when accompanied by an approved source list, can sometimes meet requirements.

Your responsibility as the printer is to find out where you fit into this ever-expanding puzzle when and if you decide to get involved with printing products having such requirements. Being awarded what appears to be a lucrative printing contract my end up being an expensive one. Read the fine print, ask questions and don't assume someone else is responsible for providing certification of ink.

Mixing Pad Printing Inks by Weight

Pad printing inks and additives should always be mixed by weight, not by volume. Pad printing inks vary in weight by volume depending upon resin system, pigment load, and more. For this reason, mixing by volume will be inaccurate.

Digital Scale Required

If you don’t have a good, digital scale, go by one. Now. Before you read on any further. Without a scale you’re completely wasting your time.

What constitutes a good scale?

- Make sure it is digital, preferable one that uses AC power, not batteries.
- Make sure it has the capacity to accommodate your required batch sizes plus the weight of the ink mixing cups (disposable PET cups are recommended).
- Make sure it measures in grams.
- Make sure it is accurate to 0.1 gram at a minimum. If you are custom color matching your own colors, your scale should be accurate to 0.01 grams.
- Make sure the measuring surface is stainless steel, so you can clean it.

Plan on spending some money. A $ 45 scale from the kitchen section of Walmart won't suffice. I recommend looking online for a scientific or safety supplier, and purchasing something like Toledo or Ohaus brand scales, such as the one pictured below.

This is an Ohaus scale with AC adapter, battery back-up, 400 gram capacity accurate to 0.01 grams. It costs about $ 400.00.

Other Ink Mixing Tools / Supplies

Once you've got a good scale, you will also need some simple mixing tools:

- Disposable ink mixing cups. I recommend clear PET or PP cups, 12 or 16 oz.
- Disposable stir sticks. I recommend tongue depressors. Most pad printing companies sell them by the case of 500 for about $ 35.00. Popsicle sticks work too, but they're kind of small.
- Disposable pipettes (eye-dropper) for adding small amounts of thinner to the ink mixing cup. Also great for use in adding thinner to the sealed ink cup's vent port once you're on the press.
- Gloves
- Calculator
- Note pad

Notice that most of the stuff listed here is DISPOSABLE. Cleaning up a mixing vessel, spatula or eyedropper instead of simply disposing of it after use is a waste of time. Plus, when you're dealing with catalysts, you can easily cross contaminate when reusing containers.

Most pad printing inks come from Europe, usually Germany. The cans have lids with little foam gaskets that get destroyed after you open the cans, especially if people don't wipe the lip of the cans clean after pouring or scooping ink out. Check with your ink supplier to see if they have locking rings to use in sealing cans after they've been opened. Some suppliers have plastic containers with screw on lids that you can transfer new inks into after opening.

Pad printing inks have a shelf life. Un-opened they can last for several years. Once opened, they last about six months unless you do something to make sure unused inks are stored in sealed containers of some sort.

Ink Mixing Procedure

The procedure I'm going to detail here is how I mix ink. Color matching inks is a totally different chapter.

You'll invariably have some differences in your mixing procedure, and that's fine provided you and everyone else in your shop does it the same way every time.

1. Turn on scale and tare / zero.
2. Place empty ink mixing cup on scale and tare / zero.
3. Add desired amount of ink to the cup.
4. Write the amount down on your note pad.
5. Tare / zero scale.
6. Wipe lip of ink can and replace lid.
7. Add catalyst / hardener (if required) according to the exact ratio recommended by the ink manufacturer.
8. Write the amount of catalyst added down on your note pad.
9. If you are using catalyst / hardener, blend it into the ink thoroughly before adding thinner.
10. Determine how much thinner to add. Manufacturers give you a range. If it's a new application that I haven't printed before I usually start just short of mid-range, using a medium speed thinner. Middle of the range being about 12-13% by weight.
11. Whatever you add for thinner, write it down on your not pad.
12. Blend thinner in to ink.

Keep Good Notes

Whatever you start with for ink weight, and whatever you add for catalyst, thinner or other performance enhancing additives, write it down and date it. That way, if you need to adjust, you can weigh those components that you add and make a note of it for future reference.

I create job set-up sheets for most of my applications. On those sheets I make a note of:

1. Ink type, color and weight
2. Catalyst type and weight / ratio
3. Thinner type(s) and weight / percentage
4. Cliché type and depth of etch (if known)
5. Pad mold number and shore (hardness)

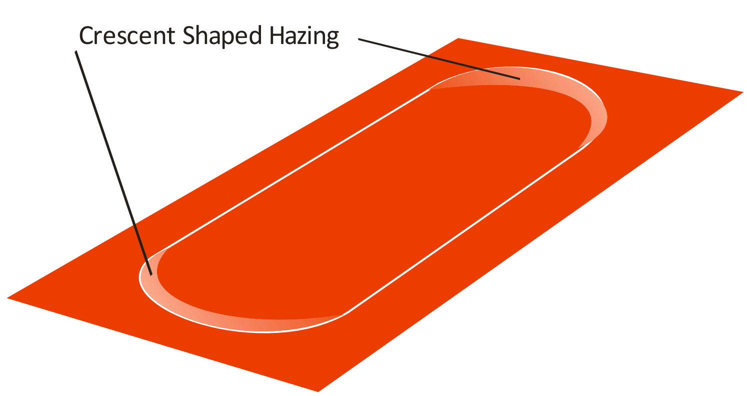
Having all of that information available is great when it comes time to troubleshoot a printing issue or make an adjustment to an ink formulation.

Mix Enough Ink

A surprising number of clients have problems with doctoring their clichés clean and / or with obtaining a quality print all because they fail to mix enough ink.

In both open and closed inking systems the ink acts much like a lubricant. Ink is to a pad printing machine what oil is to a motor. Without enough, things go wrong. Unfortunately, everyone wants to save money by skimping on the amount of ink, especially when they're setting up a press for a short run.

For sealed ink cups it is necessary to have enough ink to fill the cup at least 75% of the way full, in most cases. If you don't have enough ink to sufficiently wet up the cliché, flood the image and lubricate the ink cup's doctor ring, you will have issues. A lot of the time I can just look at a machine and know there isn't enough ink in the cup.



If you're having doctoring or print quality issues and your cliché exhibits the crescent shaped hazing illustrated above, it is a clear sign that you don't have enough ink in the cup, especially for high speed or multiple-hit applications.

Consider what's going on inside the cup and the ink cup or cliché changes direction at opposite ends of the doctoring stroke. A wave of ink forms inside the front edge of the cup as it moves backward / cliché moves forward. One the forward stroke of the cup, the wave is in the back. When the cup / cliché stops at either end of the stroke and changes direction there needs to be enough ink in the cup to wet the cliché surface all the way to the inside edge of the ink cup opposite the direction of travel. If there isn't enough ink the cliché doesn't stay wet. Ink starts to dry, and a haze forms. The cup then rides up on this haze on subsequent strokes, causing doctoring issues, leaking around the doctor blade and print quality issues.

If you're using a two component ink the fact is that you'll probably throw more ink away at the end of the press run than you used in printing the parts. It is the nature of the beast. Do yourself a favor and mix an adequate amount of ink.

Consider this: if it was oil in your car motor, and your car required 5 quarts, would you think it was a good idea to take even a short drive on 2 or 3 quarts of oil? Probably not.

Gas Build-up in Ink Cups

As you print the friction of the ink cup doctoring generates some gases within the ink cup. This is normal, and can cause the ink cups to leak during printing. As the gases build up and create pressure within the ink cup a small amount of ink "burps" out from under the doctor ring on every pass over the image. This builds up and causes problems.

Most ink designs incorporate a vent cap / solvent cap that can be loosened or even removed during printing to allow gases to escape. This will help keep pressure within the cup stable. It is OK to loosen or remove the vent cap for most applications. Just be sure to replace it before you take the ink cup and cliché out of the machine during tear-down.

Adjusting Ink for Speed

Many people consider adjusting ink for printing under different conditions to be "voodoo". If you know what is supposed to happen to the ink to make the process work, and take into consideration the ambient conditions you're printing in, it really isn't all that difficult.

Most ink systems have more than one thinner for use in adjusting "speed". There are "fast"," medium" and "slow" speed thinners. The speed of thinner depends upon its evaporation rate. The faster thinner evaporates, the quicker the ink becomes tacky, and the quicker it dries.

Technical information from manufacturers usually lists thinners as being fast, medium or slow, and a basic recommendation of how much to add, like 10 to 20%. For the majority of applications you can work with one thinner and just vary the percentage depending upon cycle times and ambient conditions, or better yet fine tune your printer's parameters to compensate for changes in ink characteristics.

When experimenting with a new application I start by setting my machine speed to achieve the desired cycle time. Then I begin testing by adding a percentage of thinner (usually medium speed) from the middle of the manufacturer's recommended range, say 15%. After allowing the machine to wet the cliché and swell the pad with a few dozen impressions on scrap, I clean the pad and test the print on the substrate. If I see a problem with the quality of the image I run this simple test:

1. Pick up the image at normal speed, stopping the machine before it prints. Look at the image on the pad. If the whole image is there, clean the pad off and proceed to Step 2. If part of the image is missing or the edges look

jagged it usually indicates that the ink is too thick (drying too quickly). Add a measured amount of thinner (so you know how much to add next time) and try again, repeating the process until you get an acceptable image on the pad. To make it easier to see the image on the pad without having to remove it or peer underneath, I like to use a little mirror such as the ones found in cosmetic compacts.

2. Once you have an acceptable image on the pad, print the substrate. Look at the print. If the print is acceptable and there is no ink on the pad you're ready to start. If the image looks smeared or transparent and there is still ink on the pad, it usually indicates that the ink is too thin (drying too slow). If you're too thin you must add ink (and, if necessary, catalyst) or slow down the machine.

Ambient conditions can also affect ink. Warmer and / or more humid conditions will make the ink dry faster, whereas colder and / or less humid conditions will have the opposite effect. This can be a problem if you have to print in fluctuating ambient conditions, especially when they go to extremes. If you're trying to print in conditions of high relative humidity (85%) coupled with high ambient temperature (90 degrees Fahrenheit), you might as well shut your machine off and go home. In particular, high humidity is your worst enemy. Why? As the old saying goes, "Oil and water don't mix." Well, ink and water don't mix. When the humidity is high there is an invisible layer of water on everything in the room, and this layer of water acts as a barrier to effective pick-up and transfer of the ink.

If you run a job all year around I recommend keeping what I call a "Mixing Matrix" to aid you in expediting ink speed adjustments. Provided you run about the same cycle time, you can make a simple chart recording temperature along one axis and relative humidity along the other. Where the two axes intersect, record the percentage of thinner required to achieve and acceptable print. Over time you'll gather enough data to make ink mixing much more efficient. Here is an example. If you mix your ink using this chart and it doesn't work, don't call me to tell me that my chart is wrong.

Ink Mix Matrix for: Job # 124 / Type STE White Ink on ABS, Single Print
Press N# 1 / 10mm steel cliche / Pad Nr. 18, 6 Shore

	64F–66F	66F–68F	68F–70F	70F–72F	72F–74F	74F–76F	76F–78F
65%–70%	D2 15%	D2 16%	D2 17%	D2 18%	D2 19%	D2 20%	D2 15% R2 2%
60%–65%	D2 14%	D2 15%	D2 16%	D2 17%	D2 18%	D2 10% R2 2%	D2 12% R2 2%
55%–60%	D2 13%	D2 14%	D2 15%	D2 16%	D2 17%	D2 18%	D2 19%
50%–55%	D2 12%	D2 13%	D2 14%	D2 15%	D2 16%	D2 17%	D2 18%
45%–50%	D2 11%	D2 12%	D2 13%	D2 14%	D2 15%	D2 16%	D2 17%
40%–45%	D2 10%	D2 11%	D2 12%	D2 13%	D2 14%	D2 15%	D2 16%
35%–40%	D2 10% V2 2%	D2 11% V2 2%	D2 12% V2 2%	D2 12% V2 3%	D2 12%	D2 13%	D2 15%

EXAMPLE

V2 = Fast
D2 = Medium
R2 = Slow (retarder)

The "Mixing Matrix" idea works pretty well for gathering data on all your ink even if you don't make one for each specific job. Just remember that different substrates, cliché depths and cycle times can produce different results. Also, different types of artwork require different amount of thinner. For example, printing a design with fine lines will require a little thinner than printing a bold design using the same ink.

Notice that the top of the matrix has the job number listed, as well as the ink type, press number, cliché type and pad number and shore. All good information to have, since changing any of those things can have an effect on the ink’s transfer efficiency.

As the example matrix indicates, you may run into a situation where you need to mix two different thinners for the same ink together to achieve a desired speed. For example, if you can't achieve an acceptable print at the cycle speed you require a medium speed thinner, and using a slow speed thinner by itself is too slow, you might mix medium and slow together. Make sure the two thinners are compatible by checking with your ink supplier if you aren't sure, and keep good notes.

Retarder should only be alone as a last resort to using a medium and slow speed thinner combination. Any time you use a retarder you should mix it with some new ink or thinner first before adding it to the ink to prevent solvent shock.

Thinning "On-the-Run"

When frequent thinning is required (For example, thinning ink every hour, several times a shift, or for several days prior to changing out ink.) It is a good idea to mix the thinner with ink (and catalyst if using two component) at a ratio of 50:50, then add that to the ink, rather than just adding straight thinner. Adding thinner frequently without adding any pigment or resin can break down the resin system, resulting in the ink losing its transfer characteristics. It can also cause the ink to look transparent, because the amount of pigment is lowered.

Re-using Ink

In closed systems it is possible to leave some types of ink (UV or single component inks) in the sealed cup indefinitely. I've seen companies load one component ink on a Monday morning and run all week before dumping it out.

In open systems using one component inks, most operators have to completely clean the ink well and accessories at the end of each shift, or day. However, this can be avoided in some cases. If you use one component inks to run the same job on a regular basis and want to avoid having to detail clean your ink well and accessories each day, try this:

1. Remove excess ink from the surface of the cliché using a rubber or paper scraper. Push the excess ink into the ink well.
2. Wipe the surface of the cliché and the cliché holder / ink well rails down with a dry rag to remove any excess ink you missed while scraping.
3. Detail clean the cliché and accessories (doctor blade, ink spatula, etc.) with a solvent dampened rag.
4. Place the cliché, in its holder / ink well into a *covered* container, along with the clean accessories. Place a clean rag dampened with thinner (not cleaning solvent) in the container, or on the cliché, and seal the container.

The sealed container and the solvent dampened rag keep the ink from drying out, just like an ink cup in a closed system. Using this method you can let open ink wells set with one-component ink for several days between runs. Sealed containers should be made of polypropylene or polyethylene.

Be aware that some thinner can be corrosive. Corrosive thinners may cause pitting of cliché and accessories if allowed to set without agitation for extended periods of time. Check with your supplier to see if the thinner you use may be corrosive.

Clean-up

Cleaning up machines and accessories can be a messy business if you let it. To make the job of clean-up easier you can buy a parts washer. Several pad printing equipment manufacturers offer automatic parts washers that re-circulate solvents. There are also a number of services available nationwide that will contract to place a parts washer in your facility and maintain it.

Automatic Parts Washer – Photo: TOSH

If parts washers are out of your budget you can use a safety can or safely covered basin of some type full of solvent and rags or paper towels. There are also industrial linen services available that will take care of your rag needs, but you can get some contaminants on those rags even after they've been "cleaned" by the service and recycled. I prefer to simply use cheap, plain old facial tissue that you can buy in bulk. Facial tissue is very absorbent and is easy to scrunch down into tiny spaces when soaking up ink.

The point of clean-up should be to keep all of your moving parts and accessories clean, safely and efficiently. The largest cost is usually the solvent. Using the thinner to clean with is rarely cost efficient. Most ink manufacturers and suppliers sell a cleaning solvent that is less expensive than thinner.

Be wary of companies that use the words "environmentally friendly" or "biodegradable" in the same sentence with the word "ink". Many chemicals by themselves can be biodegradable, until you load them up with ink. Local, state and federal regulations may prohibit you from disposing of inks, rags or empty containers. It may be necessary for you to pour all waste inks into a drum, then have the drum hauled off by a hazardous waste treatment company. While this may look expensive on the surface, it will be less expensive than getting caught dumping illegally.

16. Color Matching Pad Printing Inks

Many variables affect the way a printed color is perceived, and when any one of them changes, so does the appearance of the printed color. Just when you think you have produced exactly what the customer specified and used your best color-matching abilities, your color can be rejected because of the subjective eye of a viewer who didn't sleep well the night before.

Color matching with a color-measurement device is a science. Without one, it is an art. The very thin ink deposits used in pad printing present special challenges for ink formulators, and it is necessary to employ both the science and the art in order to satisfy your customers.

Three things must be present in order for a color to exist: an object, light to illuminate that object, and an observer (such as a person or a color-measurement device). These three components contain all the variables that affect your color-matching capabilities. The majority of the variables are contained in the object to be printed, so let's start there.

The influence of substrates

When a customer requests a particular color to be printed on an object, that color is usually selected from a color-matching system, such as Pantone, or a proprietary color master, such as a molded or painted color chip. While the color appears acceptable on the color master, it will not necessarily appear the same way on the pad-printed object -- unless you take several substrate-related factors into account.

When looking at the object or material on which you are attempting to print an image, you need to consider the following four factors:

1. The substrate's base color and surface characteristics
2. The number of print passes required to achieve the desired opacity (single or multiple hits)
3. Additives, thinners, or catalysts used in the ink

4. The application process (e.g. offset, screen printing, pad printing) that was used to produce the color master (color swatch) being matched.

Base color and surface characteristics. A substrate's surface color is the single greatest influence on the final color of the pad-printed image. When you perceive a color that has been pad printed on any given material, what you are "seeing" is the light that is reflected back to your eyes from the surface of the material and the overlaying ink layer (or layers).

Since pad printing deposits a very thin layer of ink, the light reflected back to your eyes usually travels through the ink layer, then reflects off the substrate, back through the ink layer, and into your eyes. The amount of light reflected off the substrate depends on substrate color. As you might expect, the effects of substrate color on printed-image color are most apparent when you look at lighter ink colors over darker substrates.

Surface characteristics, such as the gloss level or porosity of the substrate, also play an important role. When you view a particular color printed on two substrates of the same color but with different gloss levels, you perceive the two prints differently. Color printed on a high-gloss substrate usually appears brighter or sharper. The same color printed on a textured or porous surface appears duller.

Basically, the two textures reflect differing amounts of light back to your eyes. When light strikes the smoother, glossier substrate, most of the light is reflected at the same angle and, consequently, more reaches your eyes. A textured, porous surface, on the other hand, causes the light to reflect at a variety of angles, essentially scattering it and allowing less to reach your eyes.

The lesson to learn from this is that the more closely you can match the original color master to the substrate you'll be printing, the better off you'll be. For example, when a specified color is taken from the pages of a PMS book, it is a color that has been printed on either a coated or uncoated white paper substrate. This presents a problem if your print involves a matte black plastic substrate.

Your ink formulator may match the color master when pad printing on a glossy white paper or plastic, but the ink formulation doesn't match the color master after it is printed on the black substrate If you have a variety of substrate colors onto which a certain color must be matched, you may need more than one ink formulation for that color in order to achieve an acceptable match on all the materials.

In certain applications, you may not obtain an acceptable match without first printing base layer or two of white ink. For example, fluorescent colors cannot be adjusted to print over anything but white without losing their fluorescent characteristics. The same holds true for process colors. In both cases, the inks are transparent and need to be printed over a white substrate or a white base.

Number of print passes. As previously mentioned, when you "see" a pad-printed color, you are usually seeing the color of the substrate as well. So to reduce the influence of the substrate color on perceived image color, the printed ink layer should be as opaque as possible.

In pad printing, the thickness of the printed ink-film after drying is approximately 20% of the cliché’s etch depth. If your etch depth is a typical 0.001 in., your dried ink film for a single pass has a thickness between 0.0002-0.00025 in. This is very thin when compared to screen printing or painting. And because it is so thin, the ink layer is often not opaque enough to "hide" or minimize the effects of substrate color.

One apparent solution is to increase the cliché’s etch depth. But when you increase the etch depth beyond 0.0015 in., you reduce the transfer efficiency of the ink, and the printed result is a blurry, smudged image. So that leaves only one alternative: increasing the number of times the image is printed, a process often called double printing or multiple printing.

For the automotive industry, multiple printing is usually specified to build both the opacity and mechanical resistance of the ink film. But if your customer doesn't specifically request multiple printing, you must make the call. In making this decision, you need to determine whether you can get an acceptable color match with a single print. If you decide you need to multiple print, you then have to determine whether you can still achieve the required production rates.

In situations where you can't get an acceptable match with a single print and can't sacrifice production time for multiple printing, you need to communicate this dilemma to your ink formulator and/or your customer. In some cases, an ink's opacity can be improved to support single printing by reducing the amount of clear base in the formulation or adding more pigment.

Finally, on the subject of multiple printing, be sure that your nesting fixture is capable of holding the part in a precise location through successive prints. Also make sure that the part is properly supported and won't stretch or flex during printing.

Ink Additives

Anything added to the ink can affect its color. Thinners, catalysts, and flow agents are almost always clear, causing them to reduce the opacity of the ink.

For example, when you add a catalyst such as a hardening agent to an ink at a ratio of two parts ink to one part hardener, you are essentially reducing the opacity by 50%. Depending on the ratio, the difference between the same ink with and without catalyst may be as evident as the difference between the single and double print,

For this reason it is important that the person doing the color match is advised of any required additives and the specific ratio at which they are to be added. The color-matching technician can then make the required additions prior to verifying the formulation for color accuracy.

The Color Master

Lastly, consider the process and material used to generate the color master. Once again, your concerns relate to the ink-film-thickness limitations inherent with pad printing. Every printing process deposits a different ink thickness, so whether your color master was produced with screen or offset printing, you must adjust your expectations accordingly and make formulation adjustments when possible.

When a color master has been spray painted or molded in the desired color, it is frequently difficult to get the same level of saturation (or purity) with a pad-printing ink. So when you get a painted or molded color master, don't assume the pad-printing ink is going to have the same appearance.

The viewing environment

Light is electromagnetic energy and, as such, is part of the greater electromagnetic spectrum. The small portion of the spectrum that humans can actually see, commonly called "visible light," ranges from red (which has a long electromagnetic wavelength) to violet (which has a much shorter wavelength). Since every color you "see" is just a specific wavelength of visible light, the light that you use to illuminate the object for viewing has an effect on the perceived color of the object. If the color you're matching is to be viewed under daylight conditions, but you've obtained an acceptable match under fluorescent lighting conditions, you may not really have an acceptable match.

Even the color of the area surrounding the object has an effect on the appearance of the image's color. For example, if your customer lays the object on a dark brown desk for viewing, its color appears different than when it is viewed on a neutral gray workbench.

When you send a customer a printed swatch or sample for approval, try to make sure that the person who judges the color views it under the same lighting conditions you used when formulating the ink. Alternatively, adjust your own lighting conditions to match those the customer will use to view the color.

Now that you understand how the substrate and viewing conditions influence the color of a printed object, it's time to consider the third and final item necessary for color to exist: the observer. The observer may be either a human or a color-measurement device (such as a spectrophotometer). In either case, no two observers will view the same image in the same way.

Human observers can differentiate between roughly 10 million colors. In doing so, each individual's physiology affects the way he or she perceives a given color. A well-rested person may perceive color differently than he would when tired, ill, or stressed out. An elderly person will see color differently than a teenager. Also, certain people are less sensitive to color changes within a range of wavelengths--they may even be colorblind. So, any time a color is judged for accuracy, it is a good idea to get the input of more than one individual.

Color-measurement devices, such as spectrophotometers, measure the light reflected off (or through) an object and give the color a set of coordinates in an imaginary, three-dimensional color model called "color space." In taking measurements, each individual device is calibrated to measure the sample under a given set of conditions. These conditions involve the illuminant (light source) type, the observer's viewing angle, spectral inclusion (taking gloss into consideration), or spectral exclusion (not taking gloss into consideration).

When different devices are calibrated using the same set of conditions, ideally the measured sample yields the same coordinates in color space. In other words, they see the same color. But subtle differences in two separate instruments yield different results. In fact, the same instrument may yield different results when two consecutive measurements are taken without changing anything. But in most cases, these subtle differences don't result in color rejection.

When two separate devices are not calibrated with the same set of conditions, however, or when the color tolerance (calculated difference between two sets of color coordinates) is too narrow, problems arise. Both you and your customer might use color-measurement devices, but unless they are calibrated to see the color in exactly the same way, they will yield results that are as different as the subjective judgments of two human beings.

For example, if the person specifying the color measures the color master using spectral inclusion and you measure your color match versus the color master using spectral exclusion, you may end up with a non-acceptable result, even though your naked eye says the colors match. Therefore, if you are matching a color to fall within a specific computer-generated tolerance range, it is important that you ensure your color-measurement device is set up to use the same set of viewing conditions as the device used when the color was specified.

I prefer to use a color-measurement device as a tool in color matching. It generates a useful reference that indicates the positions of the matched color and color master in the color space. This tells me which way to adjust my formulation to come up with an acceptable match. But I don't rely solely on a color-measurement device for the purpose of accepting or rejecting a color, because on numerous occasions, I have seen them reject visually acceptable colors or accept visually unacceptable colors.

This is where the art of visual color matching comes into play. In the end, it is really people, not color-measurement devices that look at the color. For this reason, I prefer to get the visual perceptions of several people on color matches, rather than relying on tools alone.

Color management is made simpler when you consider the variables represented by the object being printed, the lighting conditions under which a printed part is viewed, and the observer who views the color. Understanding and controlling these variables can turn a daunting challenge into a profitable--and even enjoyable--area of production.

17. The Production Environment

In order for pad printing to work the ink must be able to undergo rapid physical changes. Fluctuating temperature and humidity can require you to create an ink mix matrix for every job you print, which is a time sink for any job under 10,000 pieces. Controlling ambient conditions from day to day can make your job significantly easier.

For best results you want to keep all of your product, equipment and consumable materials (especially inks and pads) in a clean, climate controlled environment. Like any printing process, pad printing is greatly affected by fluctuations in temperature and relative humidity. Storing substrates, cliché or pads in a cold room, then bringing them into a warmer environment just prior to setting up can cause problems, since a thin layer of condensation may form. Water and oil (ink) don't mix.

It is recommended that, as a minimum, at least the actual printing process be performed in an environment having a temperature between 68 and 72 degrees Fahrenheit, with relative humidity at 55%, plus or minus 5%. Again, this is shown as the “middle of the range” even on the ink mix matrix example discussed back in the chapter on inks and additives.

High humidity is the pad printer's worst enemy. If you have your printers in a room that is air conditioned and you still have humidity problems try using a de-humidifier in the room, too.

Low humidity can cause static electricity to build up on the clichés, pads and substrates. In conditions of low humidity try using a humidifier in the room.

In a perfect world every pad printer would have access to such an environment. Better yet, everyone could store all their inks, pads, clichés and substrates in the same environment. This would help eliminate a lot of environment related variables.

Chances are that the average person doesn't have this much control. In that case, you can only try to adhere as much as possible to a few general recommendations, like:

- Keep your machine away from outside walls where temperature variations are going to be more pronounced throughout the day, or season to season.
- Keep your machine out of direct sunlight, and out of turbulent airflow from heat and / or air conditioning ducts and fans.
- Try to keep your temperature and humidity from varying by more than 10 degrees Fahrenheit and 20% relative humidity in any given shift, or preferably in a given day. (3 shift period).
- Try to keep your ink, pads, hardeners and thinners in the same temperature and humidity range as you'll be printing in, or allow them to adjust to the production environment prior to using them. This is also important for your product to be printed.

Minimizing Contamination

My mission for this section was to write about eliminating contamination, but as I thought about it I realized that minimizing it is a more realistic expectation. Why? Because contaminants are everywhere: in and on the material, on human operators and equipment, on packaging, and in the production environment itself.

While the costs of minimizing contamination can range from the few extra dollars it takes to implement cleaner materials and better techniques within your existing production environment to the costs of building a clean room, the potential costs of doing nothing (losing your customers) can be even higher. Let's take a look at some common causes of and remedies for contamination.

Material Contaminants

The material itself can be a haven for contaminants. Mold release agents, grease, oils, condensation and even some additives can be a problem for decorators. For example, most decorating processes require the material's surface energy to be above some minimum. Mold release agents are a definite "no-no" because, by nature, they generally lower the material's surface energy.

Grease and oils, as well as other types of lubricants and even "cleaners" from upstream manufacturing processes can also cause issues with the initial transfer efficiency of decorations as well as problems with the subsequent adhesion and durability of the image. Cleaner-lubricants such as WD-40 on tools, conveyors and machine accessories can easily cross-contaminate product and should therefore be avoided. Once parts are contaminated they can (sometimes) be cleaned using isopropyl or denatured alcohol or "plastic cleaners" that are specially formulated for certain substrates, like ABS.

An important note: if you're forced to wipe parts to remove contaminants, be sure to change the wipes frequently to avoid simply cross-contaminating product. I've had clients that found it necessary to dispose of wipes as often as every part to avoid simply wiping the contaminants from one part to another.

If you're cleaning galvanized metal I recommend using distilled water instead of cleaning solvents, as distilled water does a much better job on galvanized metals. Also, avoid using municipal tap water to clean with as it can contain chlorine as well as fluoride and other additives that, by themselves, can cause problems with adhesion as well as the chemical and mechanical resistance of inks.

Some pre-treatment technologies include a "cleaning" component. For example, (as I learned at the Society of Plastics Engineers Decorating and Assembly Division TOPCON in Tennessee earlier this summer) plasma can remove certain kinds of contaminants at a molecular level.

Failing to adequately acclimate your substrate to the printing environment can also result in contamination since decorating processes (especially those using petro-chemical bases inks) don't like water. When you bring cold parts into a warm production environment, or warm parts into a cooler production environment you get condensation. Even if you can't see it, there is water present on the substrate material, and that water will eventually find its way into the ink.

Finally, some additives can cause problems. I was once called in to consult on an appliance panel pad printing application where the client was having all sorts of issues with adhesion as well as chemical and mechanical resistance. After a lot of investigation, we determined that the issue was the fire retardant additive that had been added to the ABS resin. It turns out that the temperature that the client was drying the printed parts at in their conveyor oven was high enough to cause the additive to leach out of the material, causing loss of adhesion that was not clearly evident until several days after the parts were processed.

Human Operators

You might expect a human operator with the personal hygiene of Pigpen (the Peanuts character) to contaminate parts, but even a well-groomed person can contaminate parts with hair, dead skin cells, cosmetics, oils, perspiration and fibers from clothing.

People should be relatively "clean" when handling parts. Hair should be reasonably restrained to avoid having it fall onto parts. This includes facial hair. Excessive cosmetics and, in extreme cases, even residue from fragrances, can contaminate parts, as can moisturizers in hand creams.

Operators and material handlers should their wash hands after handing food, and should dry wet hands with lint-free towels or a dryer.

The production environment should be kept at a temperature comfortable enough minimize the chances of people perspiring to the degree where their sweat can contaminate parts, as well as for other reasons that we will talk about later.

Operators should avoid wearing articles of clothing that shed a lot of fibers. If sweaters and fleece are necessary to keep people warm you might consider whether the cost of turning up the heat, or providing them with a disposable over-garment is cheaper than the scrap that their clothing is potentially introducing to your product. Lab coats aren't expensive, nor are "scrubs". Both are easy to clean and on the low end of the scale for shedding fibers as compared to exposed cotton or other loosely woven fabrics. And of course, there are always good old disposable garments… but some of those can be pretty hot and uncomfortable.

Equipment

Dirty equipment is bad. Air filters on machines and dryers left un-changed simply blow dirt all over the shop. Bag filters as soon as they are removed, or if you're cleaning them, take them out of the decorating area to clean them.

Spilled ink left to dry can later flake off and cause defects. When a spill occurs, clean it up immediately, before it migrates all over the place.

Plastic shavings from upstream gate removal processes invariably find their way onto screens, clichés and even dies, causing voids in images. Fork trucks and pallet jacks rolling from a dirty warehouse, across a parking lot and into your print room can introduce all kinds of contaminants.

A strong preventive maintenance program should include thorough cleaning right along with proper lubrication schedules and the close inspection of moving parts that, left maladjusted, can produce scrap via metal shavings.

Consider using a sealed system vacuum instead of a broom or a dust mop to clean up dirt, dust, shavings and other debris. Brooms and open system vacuums create clouds of tiny particulates that find their way onto everyone and everything in the area.

Packaging Materials

Packaging is a big contributor to contamination, with cardboard boxes, bins and dividers leading the way. Investigate re-useable (cleanable) plastic totes instead of cardboard whenever possible. If you must have a lot of cardboard around, consider putting a bag over the boxes before they are introduced to the decorating environment. Even if you are printing parts from bulk that are bagged inside of cardboard boxes, the boxes themselves, if left uncovered, can still introduce contaminants to the area.

Re-useable containers should be cleaned regularly to ensure that they are reasonably clean. If plastic bins or covers are damaged don't tape them back together with packaging tape, replace them. Tape on a material handling bin acts like a dirt magnet.

Wood pallets are hard to avoid, but be aware that they potentially bring a lot of contaminants into your production area. Staging palletized materials outside of the decorating space and transporting them in with a conveyor (manual roller or mechanized), or on a two wheeled cart that is dedicated to the decorating area is helpful. Of course, plastic pallets are better if you can use them.

Production Environment

Your production environment is perhaps the biggest contributor to contamination. Having walls and floors that can be cleaned is helpful. Concrete, cinder block or paneled walls are difficult to clean, whereas drywall painted with a washable paint are easier. Smooth concrete painted or sealed with polyurethane, laminated or tiled flooring are easier to clean than wood or carpet.

Stainless steel, metal or laminated work surfaces and shelves are better than wood, especially bare wood or compression board. If you have to use wood I recommend sealing it or laminating over it with contact paper that can be easily wiped clean.

When cleaning the walls, floors and work / storage surfaces use a sealed system vacuum instead of a broom for sweeping. If you have to sweep I strongly recommend spraying down a sweeping compound first as they act like a magnet for dirt and airborne contaminants, keeping them on the floor and out of the air. You can probably find spray sweeping compound at your local big box store. They can be mixed with water and applied using a pump sprayer such as those used to apply fertilizer or weed killer.

Airflow is important. Laminar airflow (uniform, non-directional airflow originating at the ceiling) and a slight positive pressure in your production environment definitely helps. Keep doors (especially overhead doors) closed. If you don't have laminar airflow capability, at least keep machines and materials away from doorways and turbulent airflow / high traffic areas whenever possible. If you have turbulent airflow, at the very least try to make it positive so contaminants are forced out of the production environment as opposed to blown in.

As I mentioned before, having controlled temperature and humidity is always helpful as it keeps operator's comfortable, enables you to acclimate your materials before decorating (to avoid condensation) and generally aids in efficient transfer of inks. If you can't control the climate for the entire production area you might consider purchasing equipment that is enclosed and controlled. We've installed several enclosed pad printing systems with their own climate control and HEPA (high efficiency particulate arrestance) filters. Soft-walled cleanrooms are also a less expensive option to full-blown, hard-walled cleanrooms.

Clean Rooms

For certain applications a clean room might be necessary. For example, if you're decorating medical devices or pharmaceutical packaging, you're probably going to be required to work in one.

The costs associated with soft and hard-walled cleanrooms varies depending upon the classification required to meet your customer's specifications. Cleanrooms are classified according to the number and size of particles permitted per volume of air.

Cleanrooms are another complete article all together. In researching I found a lot of useful information about clean room technology online at http://www.cleanairtechnology.com/cleanroom-classifications-class.php

Minimizing contamination doesn't need to be difficult, and the costs associated with implementing most common-sense "clean" practices are usually lower than the cost of contamination related scrap and rework.

The chart on the next page shows some common causes of contamination and methods for minimizing them:

Causes of Contamination	Practices for Minimizing Contamination
Material	**Material**
☐ Mold release agents	Avoid mold release agents
☐ Grease / oil / cleaner-lubricants	Clean parts changing wipes often or pre-treat
☐ Condensation	Acclimate parts to decorating environment
☐ Additives	Investigate potential negative impact on decoration
Operators	**Operators**
☐ Hair	Proper grooming / hair & beard nets
☐ Clothing	Lab coats / over-garments
☐ Cosmetics / Hand creams	Wash hands / wear gloves
Equipment	**Equipment**
☐ Filters	Remove and bag / clean outside area
☐ Ink spills	Clean immediately
☐ Plastic / metal shavings	Vacuum, avoid sweeping / include in PM
☐ Dust	Vacuum or wipe, avoid sweeping
Packaging	**Packaging**
☐ Cardboard	Re-useable plastic bins
☐ Wood Pallets	Stage outside area / use plastic pallets
Environment	**Environment**
☐ Walls	Painted or sealed as opposed to porous
☐ Ceilings	Smooth as oppose to porous
☐ Floors	Smooth, sealed, tiled or laminated
☐ Work / storage surfaces	Stainless steel or laminated
☐ No climate control	Controlled temperature and humidity
☐ Airflow	Laminar / positive pressure environment

Ventilation

Make sure that the air quality in your production area is acceptable. If you're not sure, contact your heating and air conditioning company and ask them to make a recommendation as to the volume of air you should be exhausting.

If you're unsure as to whether personnel are being exposed to levels of organic vapors that are hazardous, or are receiving complaints from employees, you can conduct an air quality test fairly inexpensively by obtaining air quality test badges from a safety or laboratory supply company. By reviewing your M.S.D.S. sheets you can find out which solvents are most frequently used. Once you know that you can order badges capable of testing exposure to one or several solvents. Your personnel wear the badges for a specified amount of time, after which you return them to the supplier, who in turn analyzes them and issues a written report.

Lighting

Lighting is important for efficiency. No one likes to work in the dark, or under a glaring spotlight. Lighting should be uniform and non-directional if possible. Cool white fluorescent lighting placed about sixty inches above the work surface provides nice, even lighting.

Remember that if you are exposing and developing your own polymer clichés in-house that the work area needs to be free of U.V. light. Even florescent lighting can give off U.V. wavelengths, so make sure you either shield your florescent lights or us a light source that doesn't contain any U.V.

If possible, the work surfaces should be a neutral color (gray), and low in gloss to allow operators and inspectors optimal viewing conditions. Colors can look significantly different when viewed over a red table top than when viewed over a gray table top.

Ergonomics

The importance of making work areas safe and worker-friendly is obvious to anyone that has spent time standing on bare concrete or sitting on a wooden stool five days a week, twisting to move materials all over the place.

Taking a little extra time to think through process flow, then positioning machines, materials and manpower accordingly is less expensive than having to move everything around after production has commenced, or having to pay for a work related injury.

Tables should be at a height that is comfortable to work at, and chairs should be adjustable. Materials should be readily accessible so that machine operators don't have to bend or twist to pick it up, print it, and place it on a rack or conveyor. Operators that must stand are much happier doing so if they're standing on a mat instead of a concrete floor.

If time permits you can set up a mock work area prior to receipt of new piece of equipment and try it out for yourself. Using the "footprint" of your new machine, tape an area of the floor off then arrange materials until you come up with the best possible material flow. Doing this can save your having to rewire electricity or relocate air and gas lines or light fixtures at the last minute.

18. Successful Project Management

People that are unsuccessful pad printing usually fail to observe one or more of the following five keys to successfully launching any pad printing operation:

1. Assign someone responsibility for the success of the project.
2. Create a reasonable time line for implementation.
3. Invest in technology.
4. Invest in training and service.
5. Invest in your people.

Assign someone responsibility for the success of the project.

Often no one is in charge of dealing with pad printing projects from cradle to grave. It is imperative that someone act as the primary project manager.

Project management includes asking a lot of questions and gathering as much information about the application as possible, including information about:

1. Specific materials you will be tasked with printing on. For example, what resins are used in molding? Is the part painted or powder coated, and if so, with what specifically? Is the paint or powder hard-coated? Is there a window for over-printing of the hard-coat?
2. Is this a new application, or an old one being "shopped around"? If it isn't new, how is it currently being decorated? By whom, using what?
3. How many colors are going to be printing, and how many colors are you going to be printing on to?
4. Dimensional drawings of the part(s), preferably with graphic locations relative to part features annotated.
5. Performance requirements for the printed graphics. For example, abrasion and chemical resistance?
6. Required annual volume?

The project manager should be in every meeting and conference call relating to the project, should be the lead person for communications in to and out of your organization, and should have the power to make decisions. For example, I recently managed a project where I coordinated communications with the project manager, design studio, material engineers and color appearance lab of a major manufacturer, teams of engineers from two different suppliers and three different facilities where the parts were being quoted, molded and decorated, the U.S. distributor of the pad printing equipment, inks, plates and pads, and the pad printing equipment manufacturer in Europe.

The project manager should also be involved in the buy-off of the equipment, whether that takes place at the manufacturer's facility, or yours. They should also coordinate anything related to shipment, as well as receipt, any required utilities (power, air, etc.), installation and operator training.

Having ten different people, all with 1/10th of the required information isn't helpful. If someone doesn't have all of these pieces to the puzzle and the ability to document them, things will invariably go wrong.

If you don't have anyone on staff with the knowledge to manage a pad printing project you may want to contract a consultant (like me) with the technical knowledge *and* organizational ability to fill the gap.

Create a reasonable time line for implementation.

If you're trapped in a "never enough time to do it right; always enough time to do it over" environment make a paradigm shift soon. If you don't have enough time to do it right, don't expect it to be right.

How long is long enough? Refer back to the paragraph above that describes project management duties. When all of those are done correctly they can reasonably be expected to take 6-8 weeks for a fairly basic application. If you're talking about automation, then you're probably looking at six to nine months from concept to production.

Contrary to what seems to be popular belief, printing systems, especially fully automated ones, are not toasters. They aren't in stock in a warehouse somewhere, ready for immediate shipment. You don't take them out of the box, plug them in, set a dial, put in parts, push down a lever and get perfectly printed toast…. um, parts.

It takes time to design and build custom pad printing solutions. Nesting fixtures need to be made, artwork needs to be done and approved, clichés need to be made, pads need to be selected or, sometimes, custom made, the right inks additives, pre- and post-treatment needs to be tested and approved, and everything needs to come together and proven. Somewhere in there, something will go wrong, so plan for contingencies.

If you create realistic time-line, explain it clearly in selling it to your client, and then follow it, everyone will be happy.

Invest in technology.

As I mentioned in the previous chapter, purchasing used or obsolete [pneumatic] machines at rock bottom prices only serves to make you the technological equivalent of your competitors.

Lucky for you, the fact that you are reading this book suggest that you are heading in the right direction, technologically speaking.

In pad printing you pay for what you get, so make sure that the solution you buy is really not just cheap. Make sure it is inexpensive. How? Insist upon a thorough production cost estimate from anyone you're looking to buy equipment from. They should be able to estimate a realistic production rate for any given equipment and consumable (ink, pads, and cliché plates) package, and from there calculate how much it is going to cost you to produce X number of parts. Costs for labor, ink, hardener, thinner, clichés and pads should all be separately itemized, with piece prices calculated separately for time and materials only, with labor, and with capital investment amortized over whatever period of time you specify. If you're supplier or consultant can't figure out how to do that, find a new one before you spend another dime.

Invest in training and service.

If you don't think that training and service is worth anything, think again. Training is always less expensive than the cost of lost man and machine hours lost trying to learn it yourself. This is where a competent supplier or consultant comes into play again. Sure, you can expect to pay at least $ 100 an hour for a knowledgeable consultant, but that's not bad when you consider you pay more than that for a plumber to make a house call for a clogged toilet.

Some pad printing solutions don't come in a box. It pays to keep that in mind when you're reviewing quotes, because "cheap" and "inexpensive" mean two different things. If two solutions appear to be identical, yet one cost a lot less, it is probably because that supplier didn't include costs for any "service after the sale" in his price, and has no intention of spending time on the phone with you after you've made your final payment. Either that or he simply doesn't know what it will all really cost you in the end, and simply doesn't care.

> Some of the best pad printing solutions don't come in a box.

Service should be your most important consideration because good service can save you from yourself. No matter how organized you are, there are going to be emergencies. When emergencies happen you'll want to be confident that your supplier or consultant is going to be there to bail you out.

Invest in your people.

No one should expect to be successful using their newest employees or temporary laborers as pad printing technicians. If your decorating department has a revolving door you're going to have a lot of problems, especially if your project coordinator is sent somewhere else after the machine is installed and the operators have received their initial training, or you have a "set-up" person that is absent from the print production area for extended periods of time.

A skilled pad printing technician is a person that can identify a problem, determine the root cause of the problem, and adjust the process accordingly. Operators need be well trained initially, and then kept current with recurring training.

Too often, this is not the case, at least not in the United States. Recently I was in Italy doing a machine approval with a client. While we were there the manufacturer had another client in at the same time. They were doing approval and training on an extremely complex system that manipulated the parts, which were in this case the body of a toy truck, to print in multiple colors on five different sides (front, back, top and both sides) within a single cycle.

I would expect that they would have had to completely set-up the system and adjust everything until they were printing perfect parts, then continue to print perfect parts for some specified period of time. After all, if the machine was going to a U.S. customer, we would have had to show them that we had developed the entire process, right down to the exact number of grams of thinner we were adding to each color, and teach them to become at least comfortable doing it all themselves, before anyone would have signed off.

Nope. The customer put in some ink, ran the machine long enough to prove that it could print something in the general location of where it was supposed to be, and signed off. By noon the machine was on a truck headed to their facility.

In another case, I saw the same thing happen in Germany with another manufacturer, only this time it was an automated system with sixteen print stations. Approved and on the truck in one day.

When I asked how it was possible that they could get away with that, the Europeans looked at me like I was had two heads and replied, “The customer already knows how to pad print. We just had to build them the machine and show them that it worked mechanically, as agreed. They’ll take care of figuring out the required plate depths, ink formulations and pad selections. Their technicians have decades of experience.”

If everyone had decades of pad printing experience in the United States, I would be out of a job.

19. Getting Started

Now that you've read about pad printing theory, machines and machine drive systems, accessories, artwork, clichés, pads, inks and plant conditions we can discuss where to begin with pad printing projects when starting from scratch.

As a consultant specializing in pad printing I hear some pretty unusual questions. It seems that people today, including those in the pad printing industry, never seem to have enough time to analyze their equipment purchases correctly, but they always seem to have enough time to do it all over again after they realize they made a bad decision.

Many initial requests for information on pad printing equipment go something like this: "I am looking for a two color pad printer. Please send all information and a price list." That is about as much information as I usually get from a prospect, which is about as useful as if I were a librarian and someone came in asking for a "book with a green cover." There are about a million books with green covers. Care to be more specific?

There is a lot of information that the pad printing sale person you will be talking to will require if they are going to do their job right. The following recommendations will help you save time and make an intelligent buying decision.

Step One: Research the Project

If you're the project manager that I mentioned in the previous chapter you want to start by gathering as much information from your customer about the part, the image, and ink requirements as possible. The following checklist is a guide to gathering helpful information.

1. Part Information

Description: ____

Production Frequency: ____

Projected Volume: ____

End Use: ____

Material(s) you need to print on:

____

____

Size: ____

Shape: ____

Texture: ____

Material colors: ____

Are part drawings available? YES NO

Drawing Type: Prototype Production

Drawing Revision Level: ____

Date samples will be available: ______________________________________

Check to see if they have photos or a 3D model.

2. Image Information

Image description: ____

Image size: ____

Is artwork available? YES NO

Location on part: ____

Image location tolerance? YES NO

If so, what is the tolerance? ____

Number of colors? 1 2 3 4 5 6 CMYK Other

Print colors: ____

Custom colors? YES NO

Are color standards available? YES NO

Is there a color tolerance? YES NO

If so, what is the tolerance? ____

3. Ink Information

Type needed: (circle one) One component Two component

Required characteristics: (circle all that apply)

Abrasion resistant

Chemical resistant

Acid resistant

Alkali resistant

Water resistant

Weather (fade) resistant

Gloss

Matte

Non-toxic

Specific testing required?   YES   NO

If so, what type of testing? ____

Is there a copy of the test specifications available?   YES   NO

Why all of the questions?

The image area, part size and number of colors dictate the size of machine you need and whether or not your need part conveying accessories.

The type of material you have assists in determining whether you need pre-treating equipment, what types of ink are likely to adhere, that additives your ink may need, and what your drying and curing parameters are likely to be.

The required production rate tells the salesperson what specific part conveying accessory you need, and whether you need automatic loading or unloading equipment, full automation, or multiple machines.

Step Two: Consult with Potential Suppliers

Make your initial contacts with pad printing equipment manufacturers that you feel may have the equipment you need. It is recommended that you contact at least three for four to receive a well-rounded selection of equipment and prices.

You could send a short e-mail with the information you gathered using the checklist earlier in the chapter, or you could call on the phone. E-mailing a formal RFQ (Request for Quote) may be more efficient for initial contacts since you don't have to wait to get through to the right person. Most manufacturer's websites specify a person or e-mail address to contact for sales inquiries, so your e-mail automatically gets routed to the correct person.

If you’ve done your checklist an RFQ shouldn't take more than a few minutes to write. Another benefit is that you can type one e-mail and put everybody's name in the BCC (blind copy) box, so no one knows who else you've made inquiries with. That e-mail then becomes your single record of initial contacts, and ensures that everyone you sent it to gets the same information. Include photos and drawing as separate attachments so that they can be updated if and when the scope of the project changes.

If you chose to call instead of sending an RFQ have the checklist readily available so that you can share the information you have gathered with the salesperson. They salesperson should ask you some clarifying questions. If they don't ask any clarifying questions it means one of three things:

1. You gave them all of the information they need to assist you.
2. They don't care about your needs enough to clarify them.
3. You are talking to the wrong person.

If possible it is recommended that you be online and on the website for the company you are calling. That way if the salesperson refers to some product while you are on the phone you can ask them to direct you to its location so you can learn more. Also, if you have a website that features the product(s) you wish to print, mention it to the salesperson and see if he or she responds by going to your site for more information, thus making some form of clarification.

If you e-mail your initial inquiries you may bet a phone call response, especially if you ask for a call back in your e-mail. You can tell a lot about a prospective vendor by talking to them on the phone. Remember those clarifying questions discussed earlier? Did they ask any? More importantly, did they appear to be listening to your answers?

Use these initial contacts to screen manufacturers. If your first impression is less than pleasing it can be a red flag for how they will handle your account in the future. Once you've narrowed down the field to no more than three companies it is time to get serious.

If your application is pretty straight forward you'll probably receive some quotations at this point. If the salesperson has any concerns (generated by asking those clarifying questions), or if your application requires some more complicated engineering, the salesperson may ask for some sample parts for evaluation prior to making a formal quotation. If this happens, take advantage of their willingness to prove their machine or process can meet your requirements. If you can obtain a video of them test printing your part ask them to enclose it with the printed sample(s) for evaluation.

Step Three: Make a Decision

Once you've received samples and quotes it comes down to comparing machine specifications and technical service. Don't allow cost to be your only deciding factor. There are good, better and best ways of approaching any application. In pad printing, "you pay for what you get". Technical service after the sale is a key factor, especially if you're just starting out.

Before you agree to purchase anything, have the supplier test print production samples using their recommended equipment and process, or at least a close facsimile thereof. Allow them enough time to prepare for proper testing, and have enough samples done so as to be comfortable with the quality and consistency of the results. Once you're comfortable with the results, the supplier and the price, buy. After the equipment is completed, being there in person for final "proving" runs is nice if you can justify making the trip. In the event that you can't physically be there, requesting a video would not be out of line.

Ask about training. Is it included? Who will be conducting it?

Consider everything, and then make your decision and stick to it. Be a nice person and call the companies that didn't get the nod. Tell them why they didn't, and don't offer to "keep them in the file" unless you mean it, otherwise they will keep calling you back to see if you need another machine.

Step Four: Prepare for Installation

Many companies fail to adequately prepare to receive a new piece of equipment, or schedule dedicated personnel and time for training. As a result, valuable training time is lost and the training is not as successful as it otherwise could (and should) have been.

There are some simple things that can be done to help maximize installation and training time. Here is a checklist.

Printing Environment: The print environment should be clean, organized and [ideally] climate controlled, and properly ventilated.

Paying me to come in to your plant and push a broom doesn't make sense. As a "clean freak" I don't mind pushing a broom, and I certainly don't think the task is below me. At a minimum, the room or area where the machine is going to be installed should be cleared of clutter and swept.

Pad printing, like any printing process, works best in a controlled environment. Even if you don't have an air-conditioned space to print in, you can minimize the negative effects of variations in temperature and relative humidity by keeping your machine out thoroughfares (where dust and dirt are stirred up by constant traffic, and rubber-necking personnel cause distractions) and away from outside walls and areas where drafts are common (overhead doors, beneath heat ducts, etc.).

Adequate ventilation is important, especially in the area where you will be mixing ink and cleaning up ink cups, cliché plates and other accessories. Once your ink is in the cup and hermetically sealed to the cliché plates, the odors shouldn't be a problem (unless your ink cups are poorly designed and / or poorly maintained).

Making Polymer Clichés In-House: Have a UV-Free zone available to work within.

If you're making polymer clichés in-house, you will also need to have a work area that is free from ultraviolet (UV) light. Overhead florescent or other lights need to be shielded so as to prevent the emission of UV wavelengths, or an alternative UV-free light source needs to be available. In a pinch, you can work in any room that doesn't have windows, and you can use a yellow "bug-light" [which is filtered to prevent the emission of UV wavelengths that bugs are attracted to].

Cliché blanks should be stored in here until they've been exposed and developed.

Utilities: The correct power and, if necessary, compressed air need to be available.

Even though my quotes specify the correct power for the equipment being installed, many companies fail to ensure that the correct power is available until I show up. I commonly lose half a day of training time running to the nearest Builder's Square or Grainger store to pick up the correct plug or parts to plumb in compressed air for pad and part pre-drying.

Check with your equipment supplier to ensure you've got the correct receptacle by simply taking a digital photo of the receptacle and messaging or e-mailing it to them. If they ship without a plug installed (as some manufacturer's do), coordinate ahead of time to ensure that you've got the right plug to wire the machine in once it arrives.

If you're installing a pneumatic machine, or accessories for pre-drying pads and parts for faster multiple color printing, make sure you've got the necessary regulator(s), hose, fittings and accessories (such as Loc-Line / www.loc-line.com) on-hand. If you're not sure what you need, ask your equipment manufacturer for recommendations. I prefer to have enough loc-line available to plumb two nozzles in for every print station (one for the part, and one for the pad), with enough in-line flow controls to adjust air volume to each nozzle independently.

Tools: The correct wrenches, screw drivers, screws, nuts, bolts, etc. should be available.

Most pad printers use metric allen / hex wrenches. I recommend a set with ball driver tips for getting in there on weird angles. Depending on how you affix your pads to pad couplers, you may also need specific metric screws (if your pads have threaded inserts in their bases) or short wood screws (which won't do all the way through the wooden bases of your pads), and something to drive them (either an adequately sized screw driver or a cordless drill with appropriate bits). Pliers and perhaps a set of vice-grips are also a good idea.

If the installing technician is bringing his or her own tools, go out and buy whatever he or she uses while they are there, so they can evaluate what you've got and point out anything that you'll need once they are done and leave with their tools.

Ink Mixing / Clean-up Supplies: It is important to have ink mixing and clean-up supplies and equipment ready.

Pad printing inks should be mixed by weight, so a good digital scale is very important. If you're color mixing and matching your scale should be accurate to 0.01 grams. $1/10^{th}$ of a gram is sufficient if you're simply blending ink with thinners and / or hardener.

Disposable plastic pipettes, mixing cups and stir sticks are important. No-wax paper cups, or plastic (PP or PET) cups and large or small tongue depressors are cheap, quick and easy to use in mixing ink. Don't waste time and money on glass or stainless steel mixing vessels and stainless steel spatulas that you have to clean. Plus, re-using vessels and spatulas can contaminate inks. Disposable plastic pipettes are great for metering thinner into your inks, and a let less messy than trying to pour ink out of a can or cup.

Thinner dispensing bottles with angled capillary “squirt” tubes work well also.

A plunger can works great for dispensing cleaning solvents when cleaning ink cups and accessories. Again, these are a lot less messy than pouring solvents out of a can.

I prefer to use absorbent towels or tissues for cleaning. Cheap facial tissue (without aloe or perfumes) work well, unless you're working in a clean room and have to use lint-free wipes.

Finally, a good fire-can with bag liners is essential for disposing of used ink cups, stir sticks, pipettes and towels or tissues. Having a lid on the can that is foot-actuated will help minimize the usually unpleasant smells associated with ink mixing and clean-up.

Work Surfaces: Prepare a space to work on.

You need a good, sturdy, level surface for mixing ink and clean-up. Ideally, tools, tissues, a plunger can and ink mixing cups, sticks and pipettes should all be within reach. I recommend a 4' x 6' table with a stainless steel top. If you can't afford stainless steel, plan on covering the surface with a media that you can dispose of when you spill ink and thinner, etc. Newsprint or brown packing paper that is dispensed from a roll is a good solution.

Finally, if you're mixing ink and cleaning up away from the printing press, invest in a wheeled cart that can accommodate the clichés, ink cups, tools, plunger can, tissues, etc. These are great for wheeling everything to and from the press from the ink mixing / clean up area without having to make multiple trips. Additionally, they help prevent spills that will invariably happen when people are trying to carry all of this stuff around. Rubbermaid makes great little plastic carts that are inexpensive and easy to clean.

People and Time: Dedicate [the right] personnel and adequate time for training.

Too often it is unclear who is supposed to be trained, and when. If you haven't pad printed before and / or have a manufacturer that provides training in their facility, it is usually better than having their technician visit you for initial training, for two reasons:

1. The manufacturer has all of the "stuff" necessary on-hand. They've got the tools, supplies and facilities available to maximize training time. No time is lost running all over the shop, or visiting the nearest hardware store or Grainger to purchase the stuff mentioned in this article.
2. The people being training can focus on the training without having to be constantly distracted with the "normal" requirements of their job.

Not everyone has to be included in training at the manufacturer. In any organization, someone has to be willing to accept responsibility for the success of the pad printing department. Someone has to "take ownership". *That* person is who needs to training at the manufacturer.

Unless you're purchasing a complicated automation, maintenance personnel don't need to visit the manufacturer for training. They can be trained in conjunction with the installation.

If you can only have training in-house, limit the number of people being trained to no more than four per shift. Beyond for people, a training cannot adequately interface with people and give them enough one-on-one, hands-on time to become comfortable.

If you don't already have dedicated operators, choose people that have exhibited the ability to follow directions, and that are conscientious. In initial training, your personnel need to be able to focus and follow directions. Later, once they've gained enough machine time to become proficient, they may revised the trainer's process. That's fine. I realize that my methodology isn't right for everyone… and as long as they can revise it in a logical manner, document the revisions, and teach someone else do it, it won’t result in bad habits that negatively impact efficiency and productivity.

There are a number of things that you can do to maximize the effectiveness of machine installation and training. Here is a checklist:

Environment

- ✓ Adequately size
- ✓ Clean
- ✓ Organized
- ✓ Ventilated
- ✓ UV-Free (cliché making only)

Utilities

- ✓ Power (Voltage, phase, plug configuration)
- ✓ Air (regulators, hoses, fittings)

Tools

- ✓ Allen / hex wrenches
- ✓ Screw drivers or drill
- ✓ Pliers
- ✓ Vice-grips

Ink Mixing / Clean-up

- ✓ Digital scale
- ✓ Disposable cups
- ✓ Disposable stir sticks
- ✓ Solvent resistant gloves
- ✓ Disposable pipettes or thinner dispensing bottles
- ✓ Cleaning tissues
- ✓ Plunger can
- ✓ Fire-proof trash can

Work Surface

- ✓ 4’ x 6’ table(s)
- ✓ Stainless steel or covered work surface
- ✓ Wheeled work cart

People and Time

- ✓ Initial training at manufacturer
- ✓ In-house training
- ✓ Ownership of the process / correct personnel
- ✓ Dedicated time / distraction free

Step Five: Get Trained

Training can be scheduled to coincide with your visit to the manufacturer for final approval of the equipment, or following delivery of the machine to your facility. If you're having training conducted in your facility, allow enough time after delivery for the machine to be unpacked and connected to utilities, and for an inventory of supplies and accessories to be made. Nothing is more frustrating to both you and the visiting technician than finding out on training day that something isn't ready.

Most importantly, dedicate the person or persons who will be directly responsible for the daily operation of the machine to training, and only training, for the entire period of time you have the factory technician in your building. All too often training goes to waste when someone who isn't directly involved receives the training, or the right people have their training interrupted.

Video record the training. In the event that no one from your organization is ever going to be trained by the manufacturer in person, ask the manufacturer to make a training video for your operators to learn from, even if it costs a couple hundred dollars. Having a training video a year or two down the road may avoid you're having to pay the higher costs for having a technician to train your personnel.

20. Quality Control Technologies

As U.S. based companies strive to become leaner, and processes for decorating plastic products become increasingly more automated, many decorators are looking for quality control technologies that can fit seamlessly into their systems.

The determining factors in deciding whether or not to employ any of these technologies is, of course, cost.

Vision Systems

For example, in the front end of automated pad printing systems cameras may be used to find parts as they are randomly spaced on conveyors, communicating their respective locations and orientations to a robot for pick-up, orientation and loading. This makes sense if you're tasked with printing thousands of parts per hour, and a human operator cannot possibly orient and load parts accurately at the required rate.

Such was the case in a recent application where we integrated cameras in a "flexible feed" application where parts were conveyed directly from a powder coating line to a pad printing system. As the parts traveled down a conveyor with random spacing and orientations, an optical sensor signaled a high resolution camera to photograph each individual knob. The camera then communicated each part's location on the conveyor belt, as well as the part's orientation, to a multiple axis robot that picked the parts up and placed them in the correct orientation before loading them onto the pad printing system's rotary table. All of this was accomplished at the rate of 60 parts per minute.

The parts were then indexed to the pad printer where graphics were applied on two different planes, then through U.V. curing. After printing and curing the parts indexed under a LED lit dome where a second set of high resolution cameras inspected each print for print quality.

The system was tasked with locating, loading, printing, curing and quality inspecting about a dozen different colors of parts. For different colored parts separate files were created for both sets of cameras. Using different lighting to increase or decrease contrast as required for the various substrate colors, the camera was able to discern and communicate the position a small, molded feature that was used for orientation.

For the image quality inspection step, the operator could set different “inspection fields” individually, for both planes, specifying the exact location and dimension of the inspection area. Additionally, the operator had the latitude to increase or decrease the PASS / FAIL tolerances by adjusting, in pixels, the percentage of “missing” pixels (seen by the camera as contrast between the substrate color and the color of the printed image) within the inspection fields.

The QC camera system includes a “heads up” display at the operator interface, with “real time” image of each part as it is inspected. If no defects are detected there is a green light shown under the photo in a scrolling, chronological record. If defects are detected, the software indicates exactly where in the inspection field the defect is, accompanied by a red light, so that the operator can inspect reported defects and troubleshoot the problem more effectively.

Of course, in that example the parts were always exactly the same shape, just different colors. Setting up such a system for a wide variety of different shapes, sizes and / or a lower volume of parts per hour probably wouldn’t be cost effective. If that scenario sounds closer to what you do, using a camera for print quality can still be beneficial, especially if your print is small in size and a human operator would be hard-pressed to see it easily. In that case, using a camera that simply magnifies the image 10x or 20x for easier viewing can make the operator more efficient at catching potential defects.

In either fully automated, high-throughput or semi-automated, lower-throughput applications, cameras can also evaluate the dimensional tolerance of the print relative to some feature of the part, saving you from printing a bunch of parts off location.

In cost justifying either solution you just need to weigh the costs of cameras versus the potential costs of scrap and / or additional inspection by human operators.

Color Monitoring Systems

Color is another area where QC is becoming increasingly important as brand owners push more requirements onto suppliers and decorators.

In some cases, the software of post-print cameras can be taught to evaluate printed color versus a master. More commonly, decorators use small, static mounted or hand-held spectrophotometers to compare the reflected color of the substrate as well as the applied graphics to standard. These handy devices can display results in any one of several different ways, depending on their specific color measurement system requirements.

For transmission color measurement, larger, bench-top instruments can be employed. For both reflectance or transmission, standards can easily be saved, named, compared and recalled with relative ease as compared to as recently as a few years ago.

Twenty years ago spectrophotometers required a 10mm diameter “target” to effectively measure a sample, limiting their use. Today there are instruments that can measure areas as small as 1.5mm in diameter, making them useful in measuring the color of smaller sample areas. Translation: I used to use them exclusively in screen printing applications, now I can use them in pad printing applications where the graphics are typically much smaller by comparison.

Don’t know where to start with regard to color management? No problem. Michigan-based X-Rite (www.xrite.com) offers one-day FOCA (Fundamentals of

Color and Appearance) seminars around the country, at a frequency of three of four each month. These seminars require no prior color training, and address color control for a variety of plastics related industries, including automotive, electronics, packaging and coatings. FOCA is a prerequisite to their more in-depth FIQC seminars, there you get to put your color theory into practice using the latest instruments and software. You can do one, or both, since they run on consecutive days in locations nationwide. While I've not attended an X-Rite seminar to date, I've attended seminars with two other color measurement companies and found them both to be extremely useful, and well worth the time.

The quality and color of printed graphics are difficult things to accurately quantify in the absence of the two technologies that I've mentioned. No two people can, or will, look at a decorated part and give you consistent feedback as to the quality of color of the graphics. We are human beings, and therefore subjective. Even over time, as we tire or our physiology changes due to stress or perhaps something that ingested, our visual acuity and color perception varies. Such is not the case for cameras.

So far we've discussed quality control technologies as they relate to pre- and post-press. What about on press?

Programmable, Stepper Motor Driven Pad Printing Equipment

Where the actual cycle parameters (e.g. pick-up and transfer stroke distances, pick-up, transfer, doctoring and part conveyance speeds and locational accuracy) of the pad printing machine are concerned, nothing beats the process control offered by a programmable, stepper motor driven machine. Unlike most pneumatic machines, where speeds and distances are still largely mechanical, and where the consistency of either is subject to fluctuations in air pressure as well as the volume of air available, stepper motors are programmable, significantly more accurate, and entirely consistent.

Thinner Metering / Viscosity Control

For the ink in the machine, some people mistakenly turn first to thinner metering devices in an effort to maintain the consistency print quality over the course of a production run, shift, or day before first looking at their plant conditions.

Any decorating process works better to begin with, and can be much more accurately maintained, in a controlled environment. If you're printing environment is subject to constantly changing ambient conditions (temperature and relative humidity), a thinner metering device is unlikely to be of much help.

In fact, regardless of whether your printing environment is controlled, a thinner metering device is of questionable value. Thinner metering does only what the name implies: meters a measured amount of thinner into the ink. Simply adding thinner without first knowing what the optimal viscosity for a given ink is and accurately measuring that viscosity on press achieves nothing of value. What you need (if you really need one… read on) is viscosity control.

Viscosity control involved a method of recirculating the ink, pumping it first from the sealed ink cup to a viscosity measuring device that monitors the resistance of vanes as they rotate in the ink, adding thinner until the resistance is within the range that correlates to the desired viscosity, and then pumping it back into the ink cup.

Metering alone simply adds thinner to ink with an unknown viscosity, usually by simply gravity feeding it in on top of the ink within the sealed ink cup, then relying on the doctoring motion of the ink cup and cliché to effectively distribute that thinner consistently. Something that is not likely to happen with any level of efficiency.

So, when is viscosity control really necessary? Only with single component inks, and only if you're tasked with mass producing the same part, in a controlled environment, with a process that is already carefully controlled, for a longer period of time (up to 24 hours) without being required to add ink to the system.

Two component inks (inks with a catalyst / hardener) change chemically until their pot life has expired. As a result, it is easy to compromise the integrity of a two-component inks, especially as they get further along in their operational pot-life.

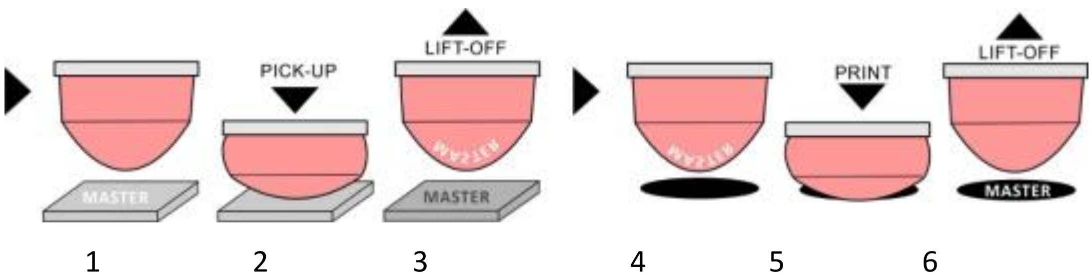
Even single component inks become compromised over time. Every time your machine doctors old, dried ink that remains in the etch and / or on the surface of the cliché is re-wet with “new” ink, while airborne contaminants are invariably introduced. If you don’t have to add ink to your system, it is probably safe to assume that you can maintain the inks transfer characteristics and chemical integrity up for up to 24 hours (3 x 8 hr. shifts). If you have to add ink, you should avoid adding new ink to old. Since that involves purging the entire recirculating viscosity control system and reloading it, it lost likely negates the purpose of having viscosity control in the first place.

Summary

There are many technologies that you can employ to ensure quality control. Vision systems can aid you in controlling part orientation, image location, print quality and color. Color monitoring systems can ensure that the color of your substrate and printed images remain consistent. Programmable, stepper motor driven machines can eliminate the potential for variations in cycle parameters, and ink viscosity control and eliminate deteriorating image quality.

21. Troubleshooting Printing Problems

When troubleshooting print related quality problems it is imperative that you first understand what a correct transfer cycle looks like at each of the six steps of the cycle.



If you aren't familiar with what is supposed to be happening at each of these six steps, go back and read "How Pad Printing Works" at the beginning of this book prior to proceeding.

The following trouble shooting guide will review possible causes and remedies for the most common problems you'll most likely experience while pad printing in your application.

1. Pad doesn't pick up ink from the cliché.
2. Poor release of ink from the pad.
3. Cliché does not doctor cleanly.
4. Poor adhesion of ink to substrate.
5. Insufficient coverage or opacity.
6. Pinholes or voids in print.
7. Print resolution poor, blurred or distorted.
8. Spider webs.

1. Print doesn't pick up ink from the cliché.

Ink: **A.** The ink may be too thick and / or may be drying in the cliché prior to the pad picking it up. To determine if this is the case, place a small amount of thinner on your finger, rub it on the print area of the pad, and quickly cycle the machine to perform a test print. Rubbing a little thinner on the pad essentially duplicates adding it to the ink in the cup. If the resulting test print is acceptable, go ahead and add thinner to the ink in the ink cup. **B.** If you're using more than one type of thinner in your ink room, you may have chosen the wrong thinner. For example, if you normally use a medium speed thinner at a certain percentage and accidentally add a faster evaporating thinner in that same percentage, it may be too fast, causing the ink to dry in the cliché before the image is picked up. Add a slower thinner if the ink appears to be drying before the pad can pick it up. **C.** If you are using a hardener, check to ensure that you mixed the ink using the correct ratios. Too much hardener can cause the ink to "turn over" sooner than normal. High humidity can cause hardener to turn over faster as well.

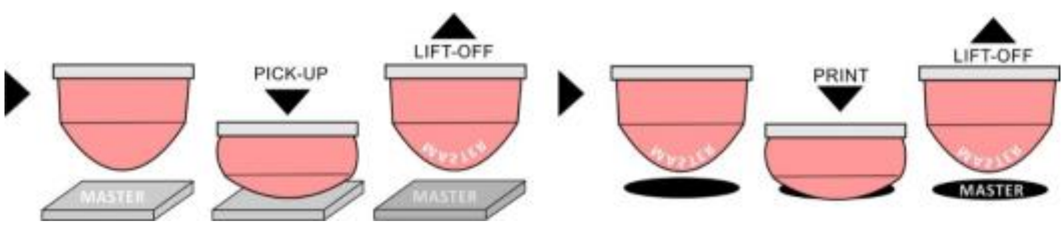
Cliché: **A.** The etch depth may be too shallow. Your cliché etch depth should (typically*) be 22-28 microns, with 25 microns being optimal. If the cliché is too shallow (below 22 microns) the ink is probably drying in the image prior to pick up. If it is closer to or over 25 microns the ink may be too thin to allow the pad to pick it up with normal production speeds / delays. If the cliché is too deep you can attempt to use it by either introducing a delay prior to pick up (to allow the ink in the cliché more time to become cohesive throughout its thickness so it can be picked up.

*etch depths when using UV curable inks will be shallower, typically between 18 and 22 microns.

Transfer Pad. A. If you're using a new pad it is possible that there is excess silicone oil on the surface and in the first few microns of the pad material. Refer to "New Pads" in the chapter on Transfer Pads. **B.** The pad may be worn out. If it is beginning to look like dry, scaly skin at the point or near the image area, replace it. **C.** Sometimes pad won't look physically dried out or otherwise damaged, but their silicone oil is depleted. Replace the pad. **D.** The point of contact for the pad may be in the image area. Move the point to outside of the image. **E.** You may be over compressing the pad on the cliché, thus trapping air. Decrease the amount of compression.

Machine: A. The machine may be cycling too fast. Slow the machine stroke speed(s) down, starting with the speed of the pad up and down in the pick-up position.

2. Poor release of ink from the pad.



Ink. A. The ink may be drying too much between pick-up and transfer. If you have air blowing at the point of the pad, try reducing the amount of air so that the ink doesn't get too dry. **B.** The ink may not be drying enough, so it transfers part, but not all, of the ink from the pad. (See illustration below) If the image is on the parts, and also on the pad after transfer, increase the amount of air blowing at the pad before transfer. This helps the ink become cohesive throughout its entire thickness (instead of dry on the outside layers and wet in the middle) so it transfers efficiently.

Cliché: A. The cliché may be too deep. Short of measuring the cliché depth, you can stop the machine after pick-up and look at the pad with a 10X loop. If the out contour (edges) of the image are not sharp, it is a good indication that the cliché (and ink in the etch) is too deep to allow the pad to efficiently pick it up in the first place.

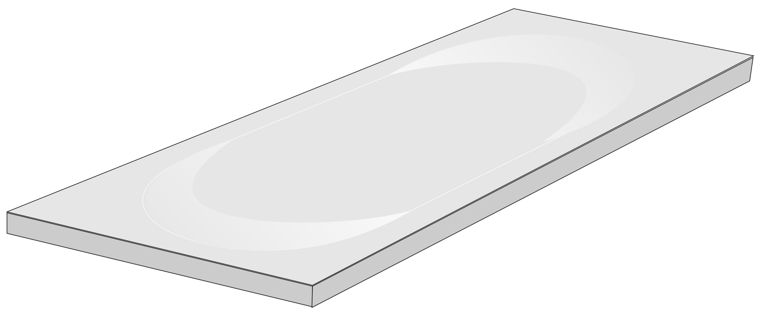
Transfer Pad. A. If you're using a new pad it is possible that there is excess silicone oil on the surface and in the first few microns of the pad material. **B.** The pad may be worn out. If it is beginning to look like dry, scaly skin at the point or near the image area, replace it. **C.** Sometimes pad won't look physically dried out or otherwise damaged, but their silicone oil is depleted. Replace the pad. **D.** The point of contact for the pad may be in the image area. Move the point to outside of the image. **E.** You may be over compressing the pad on the cliché, thus trapping air. Decrease the amount of compression.

Parts: A. The parts that you are printing on may be contaminated. Clean the parts with isopropyl or denatured alcohol and try again. If the image transfers after cleaning it indicates that there were contaminants present. **B.** If the power coating has too high or low a surface energy (measured with **Dyne Test Pens**) the ink may not transfer efficiently. The acceptable level is between 32 and 56 Dyne / cm^2. Ideally, you want the dials to measure between 38 and 42 Dyne / cm^2.

Machine: A. The machine may be cycling too fast, or too slow. If the ink image picks up but doesn't transfer from the pad to the substrate you may be drying on the pad. Speed up the machine or reduce the amount of air blowing on the pad before transfer. If the image is printing completely but there is still ink on the pad try slowing the machine down, increasing the amount of air blowing at the pad before transfer, or using a pre-print delay.

3. Cliché does not doctor cleanly.

Ink: A. If after printing for several hours the cliché begins to get a crescent shaped haze (see illustration below) on the front and back it is a good indication that you're running low on ink.



B. If the haze is consistent over the entire surface of the cliché it can mean that your doctor ring is getting dull. New doctor rings are very sharp, and as they wear the point flattens out, causing the doctor ring to not shear the ink as well. Try increasing the pressure on the ink cup, or changing the doctor ring. **C.** If the haze appears over the entire surface of the cliché several hours into the production run, it is an indication that you should add some thinner. **D.** If a build-up of ink occurs along the edges of the cliché and it is not causing a print quality problem, ignore it. Some leakage is normal. If it builds up to the point where the ink cup starts dragging it across the plate and the pad picks it up, or it is running over the edges of the cliché and getting on moving parts of the machine, stop and clean the cliché.

Cliché: A. If the problem is apparent right at start up, the cliché may not be flat on the holder. Check to ensure that the cliché is seated on the cliché holder / pins. If necessary, stop, remove the cliché and ink cup, and check between the cliché and the cliché holder for any debris or dried ink. Remove any debris and clean all surfaces so that the cliché is flat and parallel with the cliché holder.

Ink Cup: A. Check the doctor ring on the ink cup. If the edge it is more than .010" (.25mm) flat your ink cup or doctor ring needs to be replaced. **B.** The ink cup may have an uneven wear pattern from prior use. Try rotating the ink cup slightly, then doctor again. Sometimes you can locate a "sweet spot" that will improve the doctoring. **C.** There may be too much or too little down force on the cup. Try adjusting the pressure.

M**achine: A**. Sometimes doctoring too fast or too slow is the problem. Try adjusting the doctoring stroke speed.

4. Poor adhesion of ink to substrate.

Ink: A. You may have used the wrong ratio of catalyst. Check to make sure you have the right catalyst for the ink, and that you mixed it at the correct ratio by weight. **C.** If you used a two component ink and allowed the parts to be stored at a temperature that was low enough (less than 45^{O} F) to stop the polymerization of the ink film the ink will never completely polymerize. You can't restart the chemical process with some inks once it stops short of completion. **D.** You may be testing adhesion too soon. Even though the ink feels dry to the touch it should not be tested for adhesion until 24 hours after printing, and it takes 3 or more days to completely cure if you're using a two component ink. Stick to the manufacturer's recommended cure schedule prior to testing adhesion.

Parts: A. The parts may be contaminated or they may have too low a surface energy. Clean parts the test again. If surface energy is too low (not at least a measurable 38 Dyne / cm^2 investigate potential causes of contamination upstream from pad printing.

5. Insufficient coverage or opacity.

Ink: A. The ink may be too thin, so you're getting poor release of ink from the pad. See Problem 1 above. **B.** The ink may not be thick enough once completely transferred. This indicates that the cliché is not deep enough. **C.** You might not have the pad and cliché sufficiently "wet up" with ink. Allow the machine to print on automatic, using an absorbent substrate like paper to print 20 -25 times. Clean the pad and try again.

Cliché: A. The etch depth may be too shallow. For standard inks it should be between 22 and 28 microns, with 25 being optimal for most applications.

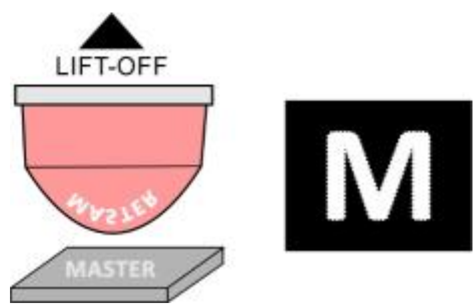
Pad. A. The pad may be worn out. Try using a new pad. **B.** The pad may not be swollen to the image yet. Print a piece of scrap 20 - 25 times, clean the pad, and try again.

Parts: A. The parts may be contaminated, with the contaminant acting as a barrier to efficient or complete ink transfer. Clean the material you are printing on and try again.

Machine: A. The machine may be cycling too fast. Slow the machine down slightly and see if opacity improves.

6. Pinholes / Voids in Print

Ink: A. The ink may be too thick. You can try this little test to see if the ink is too thick and needs thinner: Put a dab of thinner on your finger and rub it into the pad in the image area, immediately cycling the machine afterward. If the image transfers it is a good indication that you need to add some thinner to the ink. A good way to determine whether the ink has become too thick is to look at the image with a 10X loop. If the edges of the image look jagged (saw-toothed) instead of sharp, and there ink left on your pad after transfer (see illustration) this is a good indication.



Ink always dries from the outside edges in toward the center of the image, so the edges and finer detail with be the first areas of the print that deteriorate when the ink becomes too dry. **B.** Sometimes ink that is too thin can cause pinholes on rougher surfaced dials because it isn't transferring completely. Refer to Problem 1 above.

Cliché: A. The cliché may have some dried ink in the image area. Clean it and try again.

Pad: A. The pad may be contaminated. Clean the pad and test print to check. **B.** The point of the pad may be in the image. Check to ensure the pinhole / void is not the result of the point of the pad being in the image.

Parts: A. The parts may be contaminated. Clean them and try again.

Machine: A. The print stroke is too fast. Slow down the print stroke speed. **B.** The overall cycle may be too fast, resulting in the ink not achieving cohesiveness. Slow the machine cycle speed down.

7. Print resolution poor, blurred or distorted.

Ink: A. The ink may be too thin. If the image doesn't appear sharp and opaque, ink that is too wet (has too much thinner) is usually the culprit. Sometimes as a first resort you can eliminate it by adding more air blown at the point of the pad before transfer. If that doesn't work, as a second resort, try adding a small delay before transfer the give the pad a little additional time above the dial with the air blowing on it. Finally, can try adding more ink to thicken up the mixture in the ink cup.

Cliché: A. The cliché may have a poor etch quality due to wear. As the cliché progresses through its production life the edges of the etched image gradually wear until a radius appears where there should be a 90^0 angle. When the ink cup traverses the cliché it can't shear the ink off cleanly where there is a radius, and the edge quality of the resulting print becomes blurred.

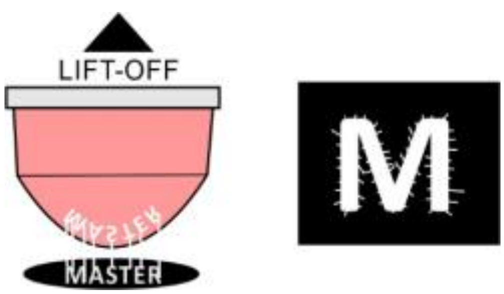
Pad: A. The pad may be over compressing on the cliché or dial, resulting in distortion. **B.** The pad may be in the wrong location. For example, the point of the pad may be too close to the image, causing it to blur the edge of the image during transfer.

Parts: A. The parts may be oily, resulting in the pad sliding during transfer of the image. **B.** The part may be moving in the nesting fixture due to burrs on the ejector pins on the back of the dials not seating correctly in the nests.

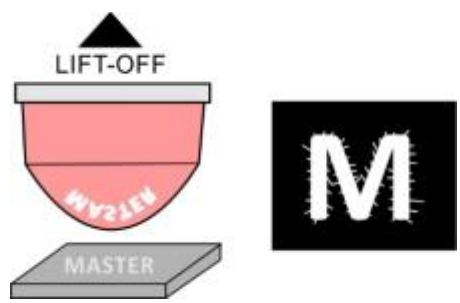
8. "Spider Webs"

Spider webs are those little "hairs" that stick out from the edges of the image after it is printed.

There are two distinctly different causes for these in most cases: spider webs resulting at transfer are normally caused by the ink being too thin, whereas spider webs resulting in image pick-up are usually caused by static charges in the ink, pad or dials.



Spider Webs at Transfer



Spider Webs at Pick-Up

When troubleshooting spider webs it is therefore necessary to stop and investigate where they are originating.

Ink: A. Spider webs at print normally are the result of the ink being dry on the top surface (the surface that sticks to the pad) and the bottom surface (outside surface of the ink film when the ink is on the pad), but wet in the middle. If the ink is too wet in the middle spider webs occur when the, during transfer, the outside surface sticks to the dials and the top surface remains stuck on the pad (because the ink film is not yet cohesive). As the pad lifts away from the dials the wet ink in the middle stretches until if finally releases and falls back onto the surface of the dials, creating the defect. In this case adding a little more air to the pad when it is above the dials prior to transfer, or using a short pre-print delay, will make the ink cohesive throughout so that it transfers completely. **B.** Spider webs at pick-up are normally the result of static charges that have built up during periods when the relative humidity in the printing environment is too low (below 40% relative humidity). If you can add humidity to the air you can normally get rid of most static issues. Sometimes it is necessary to either add anti-static blowers or air knives to eliminate the static, or add a very small percentage of anti-static paste (available from Innovative Marking Systems) to the ink during the mixing process.

Cliché: A. The cliché may be too deep, so you end up trying to transfer too much ink. When the ink film it too thick it doesn't achieve the necessary level of cohesiveness, so when you transfer you only transfer half of the ink film. The other half remains stuck to the pad. As the pad lifts away from the substrate the ink stretches and breaks.

Pad: A. The pad may be worn out / depleted of silicone oil, resulting in its not efficiently “letting go” of the ink during transfer. Change the pad.

Parts: A. Static can be a big cause for spider webs to form. Eliminate static in the printing environment. **B.** The parts may be contaminated with a substance that, once on the pad, repels the ink during image pick-up. Silicone lubricants can be a cause of this. Make sure the parts are not contaminated by inspecting them and / or performing a Dyne test.

Machine: A. The machine may be cycling too fast, particularly in the pad down and pad up in print position. Consider the image. The pad compresses onto the substrate from its point outward, displacing air as it does so. The portions of the image furthest from that point are the last to transfer. As such, they have less time to gain adhesion to the substrate than portions of the image that transferred first. When the amount of time that the outermost portions of the image have to transfer is too short, the pad lifts away prematurely. The ink can't decide if it should stick to the pad or the substrate, so it tries to go in both directions. As it stretches in both directions it reaches a point where it breaks and falls back onto the part surface. Slow the stroke speeds down, or program in a slight delay on the substrate so the pad compresses, waits a moment, and then lifts off slowly.

Other: A. Relative humidity that is too low can be a major issue. Controlling the environment will help. Low humidity is the worst culprit for static related spider webs.

Sources

Sources other than those specifically cited at the end of a given chapter include:

"History of Printing". (University of Texas, Austin website. September 2002.)

Steve Duccilli. *"Pad Printing: A Jack-of-All-Trades in Industrial Decorating".* (Screenprinting. April 1989.)

Peter Kiddell*. "Choosing a Pad Printing Press".* (Screenprinting. Date unknown.)

Sarah Buzzee. *"Shopping Smart for a Pad Printing Press".* (Screenprinting. October 1997.)

John Kaverman and Trent Pepicelli. *"Multiple-Axis Presses Step Up the Motion in Pad Printing".* (Screenprinting. June 2002.)

Dutch Drehle. *"Corona Treatment of Polyolefins".* (SGIA Journal. First Quarter 1999.)
John Kaverman. *"Pre-Treating Plastics for Pad Printing".* (Technical paper posted @ www.padprinting.net. 1999.)

John Kaverman. *"Controlling Static Electricity".* (Technical paper posted @ www.padprinting.net. 1999.)

Terry Wohl. *"High-Volume Pad Printing: An Introduction to Automation".* (Screenprinting. February 1994.)

Trent Pepicelli. *"Automate or Perish. The Future of Pad Printing in America".* (SPE

Encounter Mini-Tech presentation by John Kaverman. September, 2002).

John Kaverman. *"Pad Printing Prepress: Cliche Making in the Fast Lane".* (Screenprinting. December, 2000).

David Scher. *"Controlling Image Distortion".* (Screenprinting. July 1996.)

John Kaverman. *"Troubleshooting the Polymer Cliche Making Process".* (Plastics Decorating, October / November, 2002).

John Kaverman. *"The Facts about Clichés".* (SGIA Journal. Third Quarter 2001)

Carol Burnside. *"Cliche Selection for Pad Printing"*: Choosing the Right Plate for Your Needs. (Screenprinting. November 1994.)

John Kaverman. *"The Pads of Pad Printing".* (SGIA Journal. Second Quarter 2002.)
John Kaverman and Bob Chadwick. *"Pad Printing Textured Surfaces".* (Screenprinting. March 2000.)

Roland Sonia. *"The Pad. How to choose the right one - and deal with it, if it's still wrong".* (Screen Graphics. March - April 1997.)

Peter Kiddell and Carol Burnside. *"Understanding the Pad in Pad Printing".* (Screenprinting. May 1995.)

John Kaverman. *"Controlling Ink Characteristics for Successful Pad Printing".* (Screenprinting. November, 1998).

John Kaverman. *"Color Matching for Pad Printing".* (Screenprinting. December,1999).

John Kaverman. *"Pad Printing on Textured Surfaces".* (Technical paper posted @ www.padprinting.net. 2000.)

John Kaverman *"Pad Printing Custom Colors".* (Technical paper posted @ www.padprinting.net. 1997.)

Karen P. Nelson. *"Pad Printing Inks: The Coatings with Tacky Characteristics".* (Screenprinting. June 1991.)

Peter Kiddell. *"Understanding and Using Pad Printing Inks".* (Screenprinting. August 1995.)

Peter Kiddell and Carol Burnside. *"Press Set-up and Operation".* (Screenprinting. March 1996.)

John Kaverman. *"Optimal Conditions for Pad Printing".* (Plastics Decorating. January / February 2001.)

Peter Kiddell. *"Controlling Ambient Conditions for Better Quality".* (Screenprinting. July 1994.)

John Kaverman. *"Warm Weather Pad Printing Problems".* (Technical paper posted @ www.padprinting.net. 1998.)

Peter Kiddell and Carol Burnside. *"Pointers for Pad Printers".* (Screenprinting. May 1997.)

John Kaverman. *"Making the Right Choice - There are many aspects to selecting the right pad printing machine".* (Plastics Decorating. January / February 2002.)

John Kaverman. *"Applying Variable Data with Digital Thermal Transfer Marking."* (Plastics Decorating. April / May 2013).

John Kaverman. *"What are the Differences in Drying and Curing Pad Printing Inks? – Ask the Expert"* (Plastics Decorating. January / February 2014)

Jeff Peterson. *"Pad Printing Trends Today and in the Future".* (Plastics Decorating. January / February 2013)

John Kaverman. *"Greener Solutions for Pad Printing".* (Plastics Decorating. January / February 2011.)

John Kaverman. *"Polymer Clichés for Pad Printing."* (Plastics Decorating. July / August 2011)

Trent Pepicelli. *"TOSH: The Advantage is Built-in".* White paper. 2012

John Kaverman. *"Minimizing Contamination in a Production Environment."* (Plastics Decorating. July / August 2016)

John Kaverman. *"Quality Control Technologies."* (Plastics Decorating. April / May 2016)

Glossary of Pad Printing Terms

Pad printing has its own "lingo". Here a few of terms that you will probably hear in pad printing circles. Keep in mind that these definitions are not necessarily (scientifically) 100% correct.

Ambient conditions: The surrounding environmental conditions in your work area. For example: temperature and relative humidity.

Artwork: Black copy on a white background. All letters and graphics that you wish to print should be filled solid black, without screen tints or colors.

Catalyst: The second component in two-component inks. The catalyst reacts with the ink's resin systems and thinner to cure the ink chemically, independent of solvent evaporation.

Chemical drying: The drying and or curing process that takes place independent of solvent evaporation.

Cliche: The "printing plate" in pad printing. Comes from the German work Klische.

Cliche holder: The plate that polymer clichés are attached to. The cliche holder usually has pins for positive locations of the cliche, magnets to hold the cliche firmly in place, or both.

Closed system: A pad printing system or machine that uses a hermetically sealed ink cup instead of an open inkwell.

C.M.Y.K.: Stand for cyan, magenta, yellow and black. Also referred to as four color process printing. The order of printing need not be CMYK however. Most people print lightest to darkest.

Compression: the amount of reduction of the pads volume during image pick-up and transfer.

Conventional ink: any pad printing ink that contains pigments, a resin or binder, and an evaporative vehicle (thinner) as a standard ingredient. A U.V. ink, for example, which would not have a evaporative thinner as a standard ingredient would not be considered a conventional ink in pad printing. Water based inks are not considered conventional for pad printing either, as the vehicle (water) evaporates too slowly.

Coupler: Also referred to as the "pad coupler", it "couples" or holds the pad(s) in the machine and allows them to be positioned correctly in X, Y and sometimes Z axes.

Doctor blade: The thin steel blade that removes ink from the surface of the cliche during the "doctoring" or cleaning portion of the cycle in an open inkwell system.

Doctor ring: The sharp portion of the sealed ink cup that comes in contact with the cliche surface. If may be made of plastic, steel, or ceramic.

Dummy plate: See "cliche holder".

Emulsion: The photo (light) sensitive material on photographic film and on clichés, which when exposed to light does not develop, thus creating the image on the photographic film or cliche.

Emulsion down: term used to describe the orientation of the film used to make clichés in pad printing. It means that the emulsion should be on the "down" or back side of the film, in contact with the cliche surface.

Etch: The chemically- or photo- engraved image area of the cliche.

Fixture: The tooling or "nest" that holds the part in place for printing.

Four color: See CMYK

Flood stroke: The stoke of the machine that serves to fill the etched image area with ink.

Gravure: A term sometimes used to describe a certain type of doctor blade. Gravure blade is usually thin and highly flexible. The word comes from the gravure printing process which, like pad printing, uses printing plates having recessed images.

Halftone: the pattern of varying dot sizes using in four color process printing to reproduce continuous tone photographs. Not to be confused with a screen tint. Screen tints do not have varying dot sizes.

Hardener: see also catalyst.

Ink: A compound of pigment, resin and thinner (vehicle).

Ink brush: A brush that is sometimes used in open inkwells in lieu of an ink spatula or ink spreader bar to assist in flooding of the clichés surface.

Ink cup: The container that holds the ink in a closed system.

Inkwell: The reservoir that holds the cliche and the ink in an open inkwell system.

Line Screen Film: The film used to make the second exposure on some clichés. Line screens have a predetermined number of "dots" in a given linear distance. All of the dots are of the exact same size and center-to-center spacing. Not to be confused with a halftone or screen tint.

Mag-plate: See also Cliche Holder.

Micron: A unit of measurement commonly used in referring to etch depth or ink film thickness. One micron is equal to one millionth of a meter, or approximately .001 inches.

Mid-run: See Thin Steel Cliche.

Mono-pigmented: An ink system having only one pigment per shade (or "color"). Most color matching inks are mono-pigmented so as to avoid having the colors "shift" in the direction of a second colorant. For example, a multi-pigmented color like gray may contain several different colored pigments, whereas a mono-pigmented ink contains only one pigment.

Multi-pigmented: An ink system having more than one pigment per shade (or "color").

Nest: See "Fixture"

Open System: A pad printing system having the ink exposed to the air. The opposite of a closed system.

Pad: The vehicle for transferring the image from the cliche to the substrate in pad printing.

Photopolymer: A type of cliche that is photo-engraved rather than chemically engraved. When exposed to U.V. light energy the polymers cross-link, and when developed form a stencil.

Plate: See also "Cliche".

P.M.S.: Short for Pantone Matching System, a standardized color system used to designate specific colors.

Polymerization: A chemical reaction in which two or more molecules react to form larger molecules, eventually resulting in long chains of identically repeating molecular units. By this process photopolymer clichés, some two-component ink systems, and U.V. curable ink systems "harden".

Positive: The film or other media that holds the image to be exposed in cliche making.
Record cliche: See "Thin Steel Cliche".

Retarder: A slow evaporating thinner used to significantly slow (or "retard") the drying of the ink.

Screen Tint: A pattern of consistently sized dots used to fill an area of an image. When viewed with the human eye the screen tinted area is perceived to have a different color or saturation than surrounding solid areas of coverage having the same color.

Steel cliche: A cliche made of solid steel. In most cases solid steel clichés are 1 centimeter (10mm) or 3/8" inches thick.

Substrate: The material being printed.

Tampon: German word for "Pad". Also the origin of the words "tampography" and "tampographic", which mean "pad printing".

Texture: A word used to describe the surface characteristics of course susbtrates.

Thin Steel Cliche: A steel cliche that is not hardened like a Steel Cliche, and that is substantially thinner than a steel cliche (usually approximately 1.5 to 2.0 mm thick).

U.V. Ink: an ink that in pure form does not use a evaporative thinner, but for the purpose of pad printing must use an evaporative thinner in order to undergo the physical changes necessary to be transferred via the pad printing process.

Water-based ink: An ink that uses water as the vehicle (thinner).

Measurement Conversions

Units of measurement always confuse people. Here are some useful conversions.

To convert:	Into:	Multiply by:
Centimeters	Inches	.394
	Feet	.0328
	Meters	.01
	Millimeters	10
Feet	Centimeters	30.48
	Inches	12
	Meters	.3048
	Miles	.0001894
	Yards	.333
Gallons	Pints	8.0
	Liters	3.785
	Quarts	4
Grams	Ounces	.035
	Pounds	.002
	Kilograms	.001
Inches	Centimeters	2.54
	Feet	.0833
	Meters	.0254
	Yards	.0278
Kilograms	Grams	1,000
	Ounces	35.274
	Pounds	2.205
Liters	Cups	4.226
	Pints	2.113
	Gallons	.264
	Milliliters	1000
	Quarts	1.057
Meters	Centimeters	100
	Feet	3.281
	Inches	39.37
	Kilometers	.001

To convert:	Into:	Multiply by:
Meters	Miles	.0006214
	Millimeters	1000
	Yards	1.093
Miles	Feet	5,280
	Yards	1,760
	Kilometers	1,609
Ounces	Grams	28.35
	Pounds	.0625
	Kilograms	.028
Pints	Liters	.473
	Quarts	.50
	Gallons	.0125
Pounds	Grams	453.59
	Ounces	16.0
	Kilograms	.454
Quarts	Pints	2.0
	Liters	.946
	Gallons	.25
Yards	Inches	36
	Feet	3
	Meters	.914
	Miles	.0005682

Newtons to **Pounds** multiply Newtons by 0.224

Pounds to **Newtons** divide Pounds by 0.224

Fahrenheit to **Celsius** = $\frac{5}{9}(F-32)$

Celsius to **Fahrenheit** = $\frac{9C}{5} + 32$

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