

Getting the Best Results from Pad Printing Inks



Successful imaging relies on the right choices — and pad printing is no exception, especially when it comes to ink choices.

Standard pad printing inks are made up of resins, pigments and thinners. The resin system, sometimes referred to as the binder, forms the dried ink film. The many resin systems available include epoxy, enamel, vinyl, acrylic and polyurethane.

Pigments are colorants dispersed in the resin system. However, inks used for process applications must be transparent, so they 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 Affect Ink Properties

- Catalysts, retarders, adhesion modifiers, matte and gloss agents, and anti-static agents can be added to ink to affect its performance and appearance:
- Catalyst (or hardener) can increase the ink's abrasion, chemical and light resistance, and in some cases may increase adhesion. Catalysts react chemically with the resins to polymerize the ink film. Hardeners can also help increase an ink's gloss level.

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- Retarders — essentially very slowly evaporating thinners — are sometimes added to ink to slow its drying time.
- Adhesion modifiers will increase an ink's adhesion to certain substrates.
- Matting agents reduce the gloss level of inks. In clear resin, they'll create a frosted finish.
- Anti-static agents reduce the ink's capacity to produce a static charge and change the surface tension of the ink. If you add anti-stat to ink used in applications where multiple inks overprint, every ink that prints in succession may also need anti-stat to avoid inter-coat adhesion problems.
- Flow agents such as thixotropic paste help the ink maintain proper flow in process printing, and in some cases when printing in conditions of high humidity.

Pad Printing vs. Screen Printing Inks: Don't Substitute

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, however, have solvents designed to keep them wet so they won't dry in the screen. As a result, most "ready to print" screen printing inks are too slow to 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 pigment particle also differs in that the pigments in pad printing ink are smaller.



By **John Kaverman**, National Sales Manager, Innovative Marking Systems ►

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Solvent-Based Inks Most Common in Pad Printing

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 inks and two-component inks.

One-component inks are those that 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 and usually, it is added at a specific ratio by weight. It is very important to carefully observe the manufacturer’s recommended ratios 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, you should add the catalyst to the ink in the proper percentage and mix it well before adding thinner. Adding thinner directly to catalyst can significantly affect performance.

Carefully Follow Drying and Curing Recommendations

Drying and curing are not the same thing. Drying means bringing the ink to the point at which it is not tacky to the touch. Standard solvent-based inks dry as their solvents evaporate — within a few minutes at room temperature for most standard inks.

The chemical reaction between the catalyst and the ink in two-component ink takes place independently of solvent evaporation, curing the ink by polymerization. Curing — i.e., to bring the ink to its highest levels of adhesion and hardness — can take anywhere from minutes to several days to occur.

Most ink manufacturers recommend times and temperatures for drying and curing separately. It is especially important to observe the recommended temperatures for curing two-component inks. Printing parts with certain two-component inks, and then storing them at temperatures below 15.6° Celsius (60° Fahrenheit), can stop the chemical reaction. Once stopped, it cannot be re-started, so the ink will never fully cure. You should not test ink for performance on any substrate before the curing schedule is complete.

Baking inks are commonly used in printing on glass and ceramics. These inks

are usually two-component, solvent-based inks that require a special hardener and sometimes a special thinner. They must be baked in order to cure.

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, but have limited use due to their slow drying times.

Sublimation inks involve a special process whereby the substrate is heated and becomes porous after applying the ink. The dyes in the ink then pass into the porous surface, changing the substrate’s color. Once the substrate cools, the ink is sealed into the surface. This ink is common on computer keyboards, where even standard, two-component inks may lack the required resistance to oils and perspiration.

Because a sublimation ink actually changes the color of the material it is printed on, color matching becomes nearly impossible, and the color of the substrate must be lighter than the desired finished color.

UV-cured inks cure by polymerization when exposed to ultraviolet light. Once cured, these inks are almost “bulletproof”. However, they don’t contain any solvents to evaporate, so they don’t get very tacky. Because of this, it is difficult to pick them up and transfer them with the pad. Some manufacturers claim to be able to transfer UV inks efficiently by adding thinner to artificially improve the tack, but I’ve never been successful in doing it or seen it done by anyone else. The other problem is UV inks aren’t very opaque and don’t work well on dark colored substrates.

There are a few other inks that people transfer with pad printers, including edible inks, silicone inks and water-based inks. But because these inks 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.

Consider Substrate Properties and Requirements When Selecting Ink

All ink manufacturers and distributors provide technical information that recommends 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.

To select the right ink you need to know exactly what your substrate is, and whether

it requires pre-treatment. You also need to know what properties (such as 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.

Know the Substrate

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.

Pre-treat Substrates as Needed

Certain substrates require pre-treatment because they have very low surface energy. For example, high- and low- density polyethylene, polypropylene and polyvinyl chloride, in their natural state, typically have surface energies of around 30 dynes per square centimeter, making them too "slippery" to print. If inks are to adhere, the substrate's "wettability" must be at least 40 to 44 dynes per square centimeter.

To determine if a substrate needs to be pre-treated you can use a dyne pen. These are available from some ink suppliers, or from laboratory supply houses. Dyne pens usually come in kits. Most dyne pencils will have an expiration date. If you're going to buy a set make sure the set can test within the range recommended for pad printing (40 to 44 dynes per square centimeter).

Sometimes materials may appear to require pre-treatment when all they really require is cleaning with isopropyl or ethyl alcohol. Grease and oil from human handling, mold release agents and condensation can produce false readings, so make sure parts are clean and at room temperature prior to dyne testing.

Pre-treatment can be accomplished in one of four different ways: flame treatment, corona treatment, plasma treatment and liquid primer treatment:

- **Flame Treatment:** Flame treatment is the most widely used method of pre-treatment. Using a mixture of air and a gas such as propane or natural gas, flame treatment uses a carefully controlled, oxidizing (blue) flame to alter the substrate's surface energy. In most automated applications a specially designed flame nozzle and separate gas and air control valves are

necessary to provide a consistent flame. A common blowtorch purchased at the local hardware will suffice for occasional use, but be very careful not to under- or over-flame the treatment area.

- **Corona Treatment:** Corona treatment uses a continuous high-voltage, ion-rich discharge between two electrodes to change the substrate's surface energy. Basic corona treatment equipment is most effective on films and flat surfaces and can treat areas up to a few square inches. More sophisticated equipment can be made to treat three-dimensional objects using custom-shaped electrodes of larger dimensions. The cost of corona treatment equipment is usually only justified by a high volume of parts. Sometimes substrate manufacturers will corona treat prior to shipping materials to the printer.
- **Plasma Treatment:** Plasma treatment is similar to corona treatment in that ion-rich plasma is used to modify the substrate's surface energy. Cold gas plasma actually uses airflow to blow the ion-rich plasma generated between two electrodes onto the surface. Plasma is typically slower than corona treatment, though, because it is limited to areas only a few inches wide, and it doesn't work well inside recessed areas where airflow causes a disturbance that results in uneven treatment.
- **Liquid Primer Treatment:** Probably the least favored method of pre-treating, liquid primer is applied by dipping the substrate into the primer or by spraying or wiping the primer onto the substrate. Most primers are extremely flammable and have vapors that are harmful when absorbed by the skin or inhaled, making them rather dangerous for more than occasional use.

Carefully test any type of pre-treatment prior to production. Depending upon the combination of substrate and pre-treatment you are using, there may be a limited period of time in which you can reap the benefits of pre-treatment. For example, you may not see very good adhesion to polypropylene bottles pre-treated with liquid primer two days prior to printing.

Color: The Misunderstood Property

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Most people incorrectly assume ink will appear to be the same color regardless of the color of the substrate. Take bright colors like white, yellow, orange and pink, for example. These colors may not appear correct when printed on dark substrates regardless of whether you print once, twice or three times. In many cases bright colors must be printed on a white base. This is also a consideration when you're printing multiple colors of ink on top of one another.

Four-color process printing with cyan, magenta, yellow and black 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're going to take on any job requiring custom color matches, it would be wise to confirm you can match the color beforehand. All too often, color matches are taken for granted until timing is critical. To avoid placing yourself between a rock and a hard place at the last minute, ask your customer for color samples and, if applicable, tolerances.

In a perfect world, all color samples would be created by pad printing on a substrate with the same color, gloss and texture as the product you're trying to print. This would ensure that variables resulting from differences in substrates (e.g., color, gloss, texture) and colorants (e.g., pigment size, spacing, ink film thickness) are eliminated. Unfortunately this is rarely the case. More often than not you need to match colors with a color matching system like the Pantone Matching System, or to a plaque that 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 PMS colors close enough for acceptance by the human eye. It is when 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 you begin the production run.

Adhesion: Essential for Success

Usually — say, 99 percent of the time — no ink property is more important than adhesion. After all, what difference do 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 the substrates their inks 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. Also, ink and equipment manufacturers and distributors usually have applications labs that will test print your parts to determine the ink best suited to your application, or will recommend 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 on testing a specific image. (Even then, these charges are usually applied toward purchases.) Results should include details and exact percentages of anything that was added to the ink (e.g., hardener, thinner, adhesion modifier) and curing requirements.

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.

Catalysts Can Improve Abrasion, Chemical & Weather Resistance

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

Catalysts not only make two-component inks harder and thus more resistant, but can also increase adhesion and gloss. Some inks have UV-resistant catalysts specifically formulated to increase fade resistance for outdoor applications. Others may have a separate catalyst depending upon how they are to be cured (e.g., forced air vs. kiln dried).

An ink's technical information should indicate a ratio for mixing it with a catalyst. Because colors have different weights, most ink manufacturers specify ratio or percentage by weight, not volume. 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. Some inks have specific ratios (e.g., 4:1, 10:1) that must be strictly followed, while others have an acceptable range (e.g., 10 percent to 20 percent) within which you can add more or less, depending upon the application.

Generally, the higher the ratio or percentage of catalyst, the harder the ink will

be after it cures. Since most catalysts add gloss, a higher ratio will also yield a glossier ink. Finally, a higher ratio means a shorter pot life. Remember: I say generally, not always. Check with your ink manufacturer.

The two components should 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 printability.

Curing Time Affects Turnaround Time

Curing time becomes an issue in industrial applications where newly printed parts receive successive operations such as assembly. For example, the onset of “just-in-time” manufacturing in the electronics and automotive industries in recent years has resulted in many parts being assembled within minutes of being printed.

If you even suspect curing times may be an issue with your process, it is important that you relay that fact to your ink 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 overcommit on turnaround times unless you’re prepared to print a job twice.

Make Note of Non-Toxicity Requirements

Certain products, such as children’s toys, medical supplies and instruments, and food containers, require that inks be non-toxic. Many ink manufacturers have non-toxic formulations. However, “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.

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

Performance Certification: Learn Where You Fit

The big thrust toward ISO 9000 Certification and its equivalents has a lot of people requesting documentation from sup-

pliers that their ink meets color and/or performance specifications.

The issue of certification is murky at best. In most cases, ink manufacturers 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, manufacturers or suppliers have no control over the ink once it leaves their facilities. 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 these cases, certification 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 the finished product.

Some companies that print or buy printed products have chosen 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. This is where much of the confusion has come into play; there are hundreds, if not thousands, of different performance specifications, and no ink manufacturer can realistically afford to pay for the 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, because they control their own manufacturing process. This certificate of continuity, when accompanied by an approved source list, can sometimes meet requirements.

As the printer, it is your responsibility to find out where you fit into this ever-expanding puzzle whenever you get involved with projects having such requirements. A lucrative contract may 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.

Adjust Ink for Speed

Many people consider adjusting ink for printing under different conditions to be “voodoo.” However, if you know what is supposed to happen to the ink to make the

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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” 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. Manufacturers’ technical information usually lists thinners as being fast, medium or slow, and includes a basic recommendation of how much to add (e.g., 10 percent to 20 percent). For the majority of applications you can work with one thinner, varying the percentage based on cycle times and ambient conditions.

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 range, say 15 percent. 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 another 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 (i.e., 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 (i.e., drying too slow). In that case, 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 run a job all year around I recommend keeping what I call a “Mixing Matrix” (Figure 1) 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.

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.

You may run into a situation where you need to mix two different thinners for the

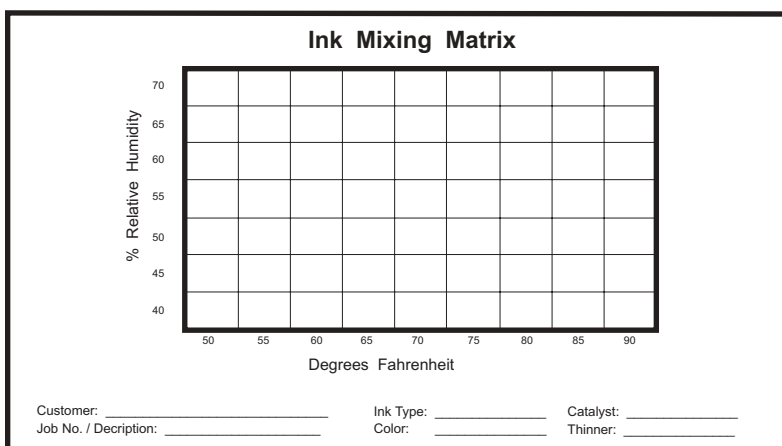


Figure 1

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. But if a slow speed thinner is too slow by itself, you might mix medium and slow together. Confirm with your ink supplier that the two thinners are compatible if you aren't sure — and keep good notes.

Retarder should only be used alone as a last resort to combining a medium and slow speed thinner. 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 (e.g., hourly, several times a shift, or 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 1:1; then add that to the ink. Adding a mixture of thinner and ink is better than adding straight thinner because adding thinner frequently, without adding any pigment or resin, can break down the resin system, resulting in the ink losing its flow characteristics. It can also cause the ink to look transparent, because the amount of pigment is lowered.

Re-using Ink: Possible with Precautions

In closed systems it is possible to leave some types of ink in the sealed cup indefinitely. I've seen companies load a 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 with 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 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.), using a rag dampened with solvent.
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 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 and may cause pitting of clichés and accessories if allowed to set without agitation for extended periods of time. Check with your supplier to see whether the thinner you use is corrosive.

Keep Clean-Up Clean

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.

If parts washers are out of your budget, you can use a safety can or a safely covered basin full of solvent and rags or paper towels. There are also industrial linen services available that will take care of your rag needs.

The point of clean-up should be to safely and efficiently keep all of your moving parts and accessories clean. The largest cost is usually the solvent, but cleaning with thinner is rarely cost effective. 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 may 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. Instead, you may need to pour all waste inks into drums, then have the drums 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.

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