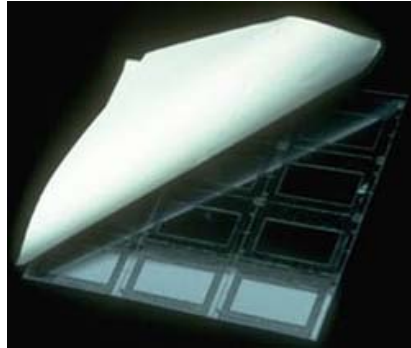


Screen Printable Adhesives

AS AN ALTERNATIVE TO PRESSURE SENSITIVE TAPES

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The intent of this article is to bring to light the capabilities of selectively applied PSAs to ensure you of a successful first experience.

Screen-printable pressure-sensitive adhesives (PSAs) are liquid adhesives that can be selectively applied and provide surface tack once dry. Although PSAs are used for many of the same applications as laminating adhesives (also known as transfer tapes), they don't have to be diecut and hand positioned. You print them only where you want them.

WHERE CAN YOU USE THEM?

One can make almost any material pressure sensitive with screen-printable PSAs. For example, these adhesives are commonly used to create permanent or temporary graphic overlays, transfers, decals and tattoos.



While these examples demonstrate the versatility of selectively applied PSAs, they also show the variety of demands placed on the adhesive.

The performance characteristics of PSAs vary dramatically. In a temporary tattoo, the adhesive must adhere to skin, yet not irritate, and be water resistant, yet remove easily. On the other hand, while the adhesive used in an automotive overlay shares the water resistance requirement, it also must be permanent and resist temperature extremes.

Screenprintable pressure sensitive adhesives (PSAs) are often ideal alternatives to laminating adhesives. Though not intended for all situations, screenprintable PSAs are an effective alternative in many applications. Knowing the performance requirements for your particular application will help you determine which adhesive system to use.

WHY SHOULD YOU USE THEM?

Economy and versatility are the leading advantages of screenprintable PSAs. These adhesives provide savings over laminating films through:



Lower materials costs

Reduced tooling costs (diecutting unnecessary)

Reduced handling (reduced production time)

The use of laminating adhesives can be up to ten times 10X more expensive than that of screen-printable PSAs. One's greatest percentage savings with water- or solvent-based screen-printable PSAs will be realized on short-run jobs in which tooling and handling costs for laminating adhesives are significant. But larger-run jobs (such as P-O-P or automotive applications) provide significant savings as well. UV cure screen-printable PSAs yield a smaller savings margin, largely dependent on volume.

ADHESIVE CONSIDERATIONS

Although PSAs are suited to many uses, it is important to understand that none are general or all-purpose adhesives. Consequently, numerous PSA formulations are available, and you must review your application requirements to select the type that will ensure success. (See following table) Screen-printable PSAs are available in three formulations: solvent mixtures, water based dispersions, and UV-curable systems. Each has specific advantages and disadvantages.

	SOLVENT BASED	WATER BASED	UV CURABLE
ADVANTAGES	<ul style="list-style-type: none"> • Inexpensive • Very good printability • Quick drying • Excellent flowout • Very good water resistance • Good peel values 	<ul style="list-style-type: none"> • Excellent UV resistance • No VOCs • 2 mil easily achievable • High temperature resistance • Very good water resistance • Good peel & shear values • Health friendly • Very good cold flow • Soap & Water clean- 	<ul style="list-style-type: none"> • High speed printing & curing • No VOCs • 1-3 mil easily achievable • H2O resist • Good peel & shear values • Health friendly • Good cold flow • Easy cleanup

		up (while wet)	
DISADVANTAGES	<ul style="list-style-type: none"> • VOCs • Solvent etching on some substrates • Flammability • Poor UV resistance • Limited temperature 	<ul style="list-style-type: none"> • Costlier than solvent based • longer drying time than UV curing • corrosive to steel • dry in the screen • ~Up to 2x the price/gal of solvent based PSAs 	<ul style="list-style-type: none"> • Costlier than water and solvent based • ~Up to 7.5x the price/gal of solvent based PSAs • temperature resistance: blocking in truck?

SOLVENT-BASED ADHESIVES

Solvent-based PSAs have the shortest learning curve, making them a good starting point. Though the market is rapidly changing, solvent systems are presently the most prevalent in the graphics industry.

Advantages of solvent-based PSAs include good printability and excellent flowout characteristics. These adhesives also offer short drying times with either air- or conveyor drying which allows the adhesives to be covered with a protective liner shortly after printing. Consequently, additional processing steps can begin soon after printing. Aside from easy processing, these PSAs offer good water resistance and peel values suitable to many applications.

Solvent-based PSAs also have a few disadvantages that one must consider. In certain cases, the solvent may attack the ink or substrate that the adhesive is printed on. This can promote increased adhesion, but solvent etching of the substrate is often considered a disadvantage. Some substrates, such as polypropylene or polyethylene will swell or distort with contact to solvents. Finally, odor, flammability and health concerns intrinsic to solvent-based products should also be considered.

WATER-BASED ADHESIVES

Expanding regulations governing worker safety and environmental issues continue to motivate companies to consider water-based adhesives. Absence of VOC's and flashpoints, combined with a low odor, make them easier to use and store than solvent-based systems. In addition, while still in liquid form, water-based PSAs can be cleaned with warm soapy water.

Water-based adhesives have technical advantages as well. Formulations based on acrylic polymers have high resistance to uv- and temperature, and are compatible with many substrates and inks. The technology also allows for high solids content.

Associated with water-based systems, some of these attributes have more to do with the resins which lend themselves to use in water-based systems. For this reason, resin characteristics will be covered briefly in this article. Strong technically and safer environmentally, water-based adhesives have a lot to offer.

Printing water-based adhesives is quite different from printing solvent-based adhesives or even water-based inks, for that matter. The freshly printed and dried film is often characterized



by air bubbles, meshmarks, and orange-peel defects.

Although a desirable quality in temporary or removable adhesives, a rough surface is generally a disadvantage where permanence and peel strength are required. However, this roughness can often be countered through use of a smooth release liner and pressure provided by stacking.



Because they are water-based, these adhesives are corrosive to steel and tend to have lower resistance to water and moisture than solvent-based adhesives. Additionally, water-based adhesives can dry quickly in the screen during printing. Once printed, however, they are slow in drying, depending on the amount of

moisture in the air and thickness of the adhesive deposit. Even conveyor drying takes slightly longer with water-based printable adhesives than solvent-based adhesives, causing a delay before additional processing may begin.

Although easy to clean in the liquid form, dried water-based printable adhesives require a solvent for cleanup. While squeegees, ink knives and equipment present no problem, the stencil is a different story. The required solvents and abrasion from rubbing may result in a damaged stencil. Additionally adhesive residue in open areas of the mesh may pose a challenge.

UV-CURE ADHESIVES

UV-curable PSAs are cured with UV radiation to become permanently tacky. They have the advantage of being 100% solids, so unlike solvent- and water-based adhesives, the wet and dry film deposit theoretically remains the same. (In practice, they differ.) In addition, UV-based adhesives can be printed and process at high speeds.

Despite the encouraging advantages of the UV-based systems, there are several drawbacks. Health and safety questions such as skin irritation and exposure to monomers have been raised. Plus, curing requires special equipment for a product with a narrow curing window. *Undercuring* results in a soft film with low peel value and low temperature resistance while *overcuring* produces a film with low tack.

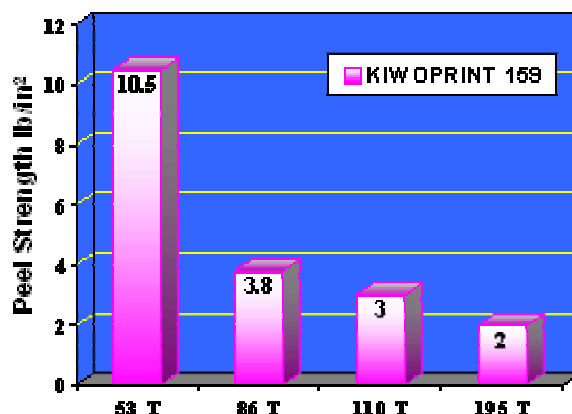
Further difficulties result not from the adhesive itself, but rather from related variables. The cure level will be influenced by wet film deposit, substrate temperature, and substrate color, to name a few. Also, when re-exposed to UV radiation (including sunlight), UV adhesives can continue to harden and become brittle. In many P-O-P applications, such as window displays, this can be a major concern. Finally, the adhesives are quite expensive and limited in heat resistance. The degree of resistance varies widely by brand, but water- and solvent-based PSAs can withstand temperatures of 180 – 360°F (82-182°C) and even higher, while UV adhesives generally fall within 150-200°F (66-93°C).

HANDLING THE ADHESIVES

Viscosity contributes considerably to the performance of a printable PSA. In most cases the manufacturer supplies the adhesive at an appropriate viscosity for printing, but temperature, humidity, and time may cause viscosity changes. To prevent problems, avoid the extremes in modifying and storing the product, and follow the product literature.

Ambient temperatures, in the neighborhood of 68°F (20°C) are often best for storing and printing PSAs. Cooler temperatures can cause the adhesive to become more viscous. High viscosity can prevent the adhesive from filling the cells of the mesh in the image area, reducing both wet- and dry-film thickness. Reduced dry-film thickness is undesirable because it directly reduces peel strength as seen in the following graph.

Peel Strength vs. Threads per Inch



Adhesive flowout is also affected by cooler temperatures. While solvent-based adhesives typically have great flowout, this may be retarded by lower temperatures. However, water-based adhesives experience the most pronounced effects from low temperature. Even under ideal temperatures water-based printable PSAs exhibit only average to fair flowout and often rely on the smoothness of the release liner and stack pressure to remove mesh marks. Cooler temperatures during printing emphasize any inherent resistance to flowout.

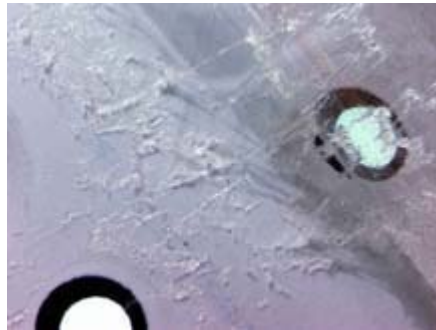
Water-based adhesives print best when the humidity is rather high. Evaporation due to low humidity will rapidly result in increased viscosity. Deposit thickness and flowout will be affected first, then the adhesive will begin to block the image areas of the mesh. Unlike solvent-based adhesives, water-based adhesives do not rewet. As water evaporates from the adhesive, the resin particles (micelles) come closer and closer together, eventually coming in contact with one another to form a film that is difficult to dissolve.

Once water-based adhesive begins to dry in the mesh, quickly remove the screen for immediate cleaning. Install a new screen, increase humidity around the press if possible, and begin printing once more. In most cases, the screen can be cleaned on press to some degree, but best results are achieved with warm, soapy water. Most problems can be avoided before one starts printing by increasing and maintaining higher humidity around the press.

SPECIFICATIONS

PEEL VALUES

Though many performance characteristics are associated with PSAs, peel value is probably the most asked about and the most specified by engineering standards. Peel strength is the force required to remove a PSA label of specific dimensions from a standard substrate at a set speed and angle after the label has been applied under specific conditions of time, pressure, and in some cases temperature and humidity. Whether you need to meet a set peel value or simply want to compare the strength of a screenable PSA to a laminating adhesive, you must understand that peel value is influenced primarily by the dry-film thickness (DFT). The greater the DFT, the better the peel value.



If you compare laminating adhesive to screenprintable PSAs, remember that the former can be supplied in thick films (above 2 mils), which can, in some cases provide slightly better peel values. Some screen-printable PSAs can be printed to produce a 2 mil DFT, but films thicker than this are more of a challenge to achieve and not necessarily needed. Above 2 mils, the increase in peel strength begins to level off for both laminating adhesives and printable PSAs. While there are jobs which specify 2.5-5 mil deposits, many specify deposits and peel values attainable with screenprintable PSAs. (CHART)

Most product literature that lists peel values will indicate the deposit thickness or mesh count and substrates used to perform the test. Keep in mind that with different substrates, deposit thicknesses, or processing conditions, one often achieves quite different values with the same adhesive. The following graph illustrates the variety of peel results obtained from one printable PSA when applied to a spectrum of substrates.

Additional performance characteristics commonly specified for PSAs include:

- Solvent resistance
- Temperature resistance (or service range)
- Tack
- Shear
- Service life
- Thickness
- Surface aberrations (irregularities or voids)

While various performance values will appear on the product's technical sheet for a given set of specifications; deposit thickness, number of resulting surface aberrations and service life may depend on processing, mesh selection, substrate, etc. This data is usually provided as a guide or starting point for you to begin testing. It is always recommended to run tests to determine the production results that you can expect with your shop conditions.

SUBSTRATES

Once you understand basic adhesive capabilities, you can begin to select an adhesive for the job you have in mind. For most jobs, the substrate and the application surface (often called the "second substrate" in this market) are determined by the customer or the job itself. In most cases, general adhesive/substrate compatibility will be listed on specification sheet. However, the manufacturer cannot be expected to guarantee an adhesive on a particular substrate (or ink for that matter.) There are far too many substrates, inks and manufacturers for any adhesive manufacturer to test and guarantee compatibility. In addition, the performance of the adhesive is greatly dependent on variables that can only be controlled by the printer.

Testing the adhesive's performance by simulating the conditions it will endure will give you the best indication of success. *Though testing is necessary, it does not have to be difficult.* First one needs to print the adhesive onto the substrate or ink specified for the job. Keeping in mind that you should use identical screens, screen tension, squeegee angle, squeegee pressure, press setup, and other processing parameters in the test and in production.

Then, after drying, apply the decal to the second substrate. Lastly, subject the applied decal to specified/anticipated conditions (e.g., weather, mechanical stress, UV radiation) and record the results. Where peel or shear values must be met, there is usually a standard testing procedure which will dictate the 1st and 2nd substrates, substrate width, adhesive thickness, dwell time before peel, etc.

Even when the substrate is specified for a job, review several factors before starting. For a good bond with standard pressure sensitive adhesives, the substrate surface tension must be greater than 35 dynes. If not listed on the technical data sheet, consult the manufacturer for the dyne level of a particular substrate. It is also advisable to test the surface tension yourself.

Although most substrates have sufficient surface tension; some (such as polyethylene) need to be flame or corona treated to enable bonding. The surface tension of polyethylene, which is roughly 4-5 dynes untreated, will increase to approximately 38-40 dynes after corona treatment. The substrate should be printed shortly after treatment since the surface tension decreases over time. After extended storage periods, it's best to test the surface tension just before printing in case additional treatment is needed.

As with inks, if the adhesive has to be printed in register with ink or diecutting lines, you must know about and plan for any substrate instability. PSAs are flexible enough to withstand dimensional changes in the substrate while maintaining deposit thickness; however, in extreme cases of substrate distortion, always test the deposit thickness if it is a critical variable.

The absorption characteristics of the substrate are of concern when the applied decal will be subjected to water, oils or solvents. If these materials are easily absorbed by the substrate, it is imperative that the adhesive resist them. Substrate porosity is a related concern. Aside from increasing absorption tendencies, the more porous a substrate the harder it will be to achieve

substantial deposit thickness. This is particularly true with solvent-based adhesives and any adhesive of low viscosity (2,000-4,000 mPas).

Finally, surface roughness plays an important roll in adhesive performance. PSAs depend on thorough wetting of the surface (i.e.:100% contact) to provide maximum adhesion. When the adhesive fails to wet the surface of the substrate it is printed on, and the subsequent decal or overlay is applied to a smooth surface, the adhesive may cling to the second (application) surface when the primary substrate is peeled away. On smooth to minimally rough surfaces (to 1 micron), it's easy to completely wet the surface because the squeegee applies sufficient pressure for the adhesive to overcome this roughness.

Textured polycarbonate with higher roughness values (5-10 μ) provides more of a challenge. Use an adhesive with good flow-out for best results; in many cases this will be a solvent-based adhesive. Overcoming this degree of roughness can and in many cases will decrease the deposit thickness by 50% or more. Sandblasted surfaces with a roughness of 30-40 μ would best be handled by transfer tapes.

RELEASE LINERS

When selecting liner material, consider that it must have enough surface tension to stay in place during post-press operations, such as diecutting. Obtain samples of various liners and test to see if they're suitable for your needs.

Basic liners are silicone coated paper, polypropylene or polyethylene. The silicone is cured to the liner by exposure to heat, UV radiation, or electron bombardment. While any of these methods can be used with paper and polypropylene, polyethylene can only employ uv radiation or electron bombardment to cure the silicone. (the heat required to heat cure the silicone would damage the polyethylene.) Heat-cured silicone films are the most trouble free liner for use with PSAs. Although uv-cured liners can be used, be aware that the manufacturer must employ excellent quality control to eliminate silicone migration. If you plan to purchase uv-cured liners, it's a good idea to get to know your manufacturer.

Also, never assume that you can use the discarded liner from laminating films; what works for one adhesive might not work for another. *If you recycle liner material, test for compatibility before using.*

PRINTING PARAMETERS

INFLUENCE OF THE MESH

How well screenprintable PSAs perform is greatly dependent upon the printing procedures you employ. Remember that peel strength is directly related to DFT – the greater the DFT, the greater the peel strength. Selecting the proper mesh, stencil thickness, squeegee durometer and other deposit parameters will greatly affect your results. DFT is determined primarily by the mesh count and the emulsion thickness, as well as the solids content of the PSA. The theoretical wet film thickness (WFT) of a given mesh is normally listed on the mesh manufacturers specification sheet and can be used together with the solids content to calculate DFT.

$$\% \text{ SOLIDS} \quad \times \quad \text{WFT (Wet Film Thickness)} \quad = \quad \text{DFT (Dry Film Thickness)}$$

For example, an adhesive with 64% solids printed through a 156T tpi mesh with a WFT yield of 1.69 mils (42.9µ) would produce a calculated DFT of 1.08 mils (27.5µ). While this DFT may provide sufficient adhesion for many decals and P-O-P applications, nameplates and automotive appliques will require greater adhesion and thus greater DFT. When the same adhesive from above is printed through a 54T mesh, it would yield a calculated DFT of 3.3 mils (83.5 microns). Remember that these are theoretical values based on calculations; the DFT you achieve in reality may be slightly lower.

Thread Count:	54T	86T	110T	195T
Theoretical WFT:	79.5µ	47.6µ	36.9µ	23.9µ
Theoretical DFT:	50.1µ	30.5µ	23.6µ	15.3µ
Actual DFT: (Difference measurement)	~45µ	~25µ	~20µ	~10µ

In the previous examples, DFT was calculated for adhesive used straight from the can, often the case with waterbased adhesives. (Reducing water based adhesives tends to cause a great amount of foaming.) Solvent based adhesives, however, are frequently modified for better flowout or to eliminate bubble entrapment. Be aware that reducing the adhesive for printing will reduce the solids content and, therefore, the DFT. Consequently, as FIGURE 7 shows, your calculation for DFT changes to include the percentage that the adhesive was reduced.

Though reducing the adhesive will change DFT, both the WFT and coverage remain the same. When the specific gravity of the adhesive is near 1 g/cm³, a ballpark figure for coverage can easily be determined using the theoretical WFT. In this case, the WFT expressed in microns is roughly equal to the number of milliliters per meter squared. To calculate the ballpark coverage in square feet per gallon, simply divide 1633 by the WFT expressed in mils.

CALCULATED COVERAGE GIVEN ADHESIVE DENSITY OF APPROXIMATELY 1 g/cm³

UNIT STANDARD	COVERAGE FORMULA	EXAMPLE with 110T threads/in
US units:	1633/ WFT in mils = ~sq.ft/Gal	1633/ 2.51mils = ~ 650 sq.ft/Gal
Metric units:	WFT in microns = ml/ sq.m	WFT of 63.7ml/ sq.m

These calculations are meant to give you an estimate of the coverage you can achieve. However, you will find that actual yield will vary from one press to another, not to mention the influences of squeegee type, squeegee angle, etc.

How does screen tension influence adhesive printing? Low tension typically causes problem of smearing beyond the image edge and can cause numerous bubbles in the adhesive deposit because it provides slow release of the screen from the substrate. This is particularly the case with water-based adhesives and is most often seen at the last location of mesh release. A positive step toward controlling PSA printing is stretching your mesh to the levels recommended by the manufacturer.

The orientation of mesh threads to the design has an effect on the printed PSA. Adhesive printing is similar to graphics printing in terms of straight lines and fine detail. Though PSAs will flowout to some degree, a "saw-tooth" or "stair-step" effect may result when the image edges are positioned parallel to warp/ weft threads. These elements are best reproduced when run across the knuckles of the mesh instead of running parallel to the threads.

STENCIL SELECTION

Choose a stencil that will give you the best resistance to the adhesive base, whether water, solvent, or UV. A few good stencil systems with resistance to both water- and solvent-based PSAs are available if you plan to use more than one type of adhesive.

Stencil thickness is another consideration. The thicker the adhesive layer one deposits, the greater the adherence value. One may want to select a stencil with high solids content which can provide a high emulsion over mesh ratio, and, consequently, a greater adhesive film thickness. Be careful not to overdue it, however, since too high an emulsion over mesh ratio can inhibit release of adhesive from the stencil to the substrate. For best results, do not exceed 20% emulsion-over-mesh ratio.

PRESS CONSIDERATIONS

Either a 4-post or 2 post flat bed, a clam-shell, or a cylinder press can be used to print PSAs; however, the ease of printing will be quite different depending on the press type used. The rheology of printable PSAs makes them almost ideal for a cylinder press. A two- or four-post flatbed press is the second-best choice because the screen is lifted away from the adhesive all at once, minimizing the occurrence of orange-peel. The clamshell press can be used, but it possesses the greatest challenge to the PSA printer. With a clamshell model, the gradual lifting of the screen from front to back tends to exaggerate the orange-peel effect common to printable PSAs, particularly water-based ones. Appropriate screen tension and careful adjusting of the press, peel, and squeegee on a clamshell press minimize the effect.

The ability of the press to print with either direct contact or off-contact will also affect the adhesive-film deposit, depending on the type of adhesive one is printing. Solvent-based adhesives print best with off-contact, while high viscosity water-based adhesives characteristically print best with direct contact. (Conversely, lower viscosity water-based adhesives print better with high off-contact.) These are general tendencies and are somewhat dependent on your press. Print a test run to familiarize yourself with the adhesive before beginning production. Remember it is best to change only one variable at a time when performing such a test.

The press should also be equipped with a vacuum table to hold the substrate in place. This will help one overcome and problems with adhesive tack or poor ink release.

PRINTING THE ADHESIVE

PSAs can challenge one's screen printing skills. If a solvent-based adhesive starts to dry in the screen, it can be re-dissolved to some degree by fresh adhesive. To compensate for evaporation in the screen, solvent-based PSAs are often thinned (up to a maximum of 10%) and printed like a "normal solvent-based ink."

Water-based adhesives pose a different challenge. When water evaporates, the adhesive resins come closer together and begin to form a pressure sensitive film. This film is irreversible and can clog the open area of the mesh. Since thinning water-based adhesives is not recommended, design your printing process to prohibit a film from forming in the screen. Keep starts and stops to a minimum.

Water will evaporate under most conditions which are comfortable to humans and ideal for printing operations. The goal is to slow the evaporation rate so the adhesive is used faster than water evaporates from it. The following techniques can be used to slow evaporation of printable water-based adhesives:

1. Use chemical additives to absorb and retain water. Normally these additives are already present in the largest possible percentage which will allow the adhesive to dry and which will not adversely affect the adhesion.
2. Raise the relative humidity to 50-60% in the printing room. This can be accomplished with a humidifier or by engineering the plant to provide this level of humidity. Increasing humidity will also help prevent static electrical charges.
3. Equip the press with a cool steam or misting device.

Just before adding water-based adhesive to the screen, it is helpful to wipe the complete stencil (top, bottom, and open areas) with a damp cloth. Whether using polyester or stainless steel mesh, moistening the screen before printing will reduce the potential of "dry-in" at the beginning of the print run. If the run must be stopped, there are two ways in which one can handle the adhesive:

- Flood the image area with adhesive, then cover both the top and bottom image area of the screen with a damp cloth. In addition, cover the adhesive well. Before printing resumes, remove and discard any adhesive which has formed a film.
- Remove all adhesive from the screen then spray both top & bottom of the screen with water. Place a damp cloth over the image area.

Here are some other printing techniques to try with water-based PSA. (Of course, not all can be applied at once.)

1. Fill the screen with enough adhesive for only a few minutes of printing (maybe 10-15 min). When the adhesive is almost gone, remove and dispose of the residue, fill the screen with fresh adhesive for 10-15 minutes of printing and repeat. With a little practice, one can implement this quickly and with little waste.

Another alternative is to use an automatic ink feeder. But be careful when printing with water-base adhesives- they can dry in the feeder and cause additional headaches. Most importantly, use a low-shear pump or auger which puts a minimal amount of shear on the adhesive to help prevent breakdown of the dispersion.

2. Adjust the flood bar so that a relatively thick layer of adhesive covers the screen. Some presses cannot do this, so the cycle time must be fast enough to prevent the adhesive from drying in the screen between prints.

3. Set the off-contact to zero (or the minimal possible) and print using a slow, thick flood stroke combined with a medium to fast print stroke. Reduce the cycle time to prevent the adhesive from drying in the screen. Next "pop" the screen from the substrate all at once, which will create an even surface over the entire print while "pulling" the adhesive from the cells of the mesh. To make sure the screen and substrate will separate, it's best to have a strong vacuum to hold the substrate down as the screen is pulled quickly up-and-away from the print.

If the water-based adhesive begins to dry in the screen, don't fight it. Wash the entire screen, both top and bottom, with warm soapy water. This is normally done off the press, but may also be done on press. If any adhesive remains, it will have to be removed with an emulsifying solvent, before rewashing.

If one intends to save the screen at the end of a print run, quickly remove it from the press and immediately washed it with warm soapy water. Any adhesive remaining in the screen at the end of the print run, can be saved for re-use only if it has not discolored or begun to form a skin. Save the adhesive in an airtight container. If the adhesive does not fill the container, place plastic on the surface of the adhesive to prevent a skin from forming in the container.

SQUEEGEE

Use a squeegee of 60-75 shore A for printing PSAs. A round profile works best when a thick deposit is desired. A sharp-edged squeegee can also be used, and in some cases, provides an even smoother surface. This is particularly true with solvent-based adhesives. The drawback is that the sharp edge will only achieve about 50% of the deposit possible with the round edge.

The angle and pressure of the squeegee are also important to the adhesive deposit. Test for the angle which provides the most complete ink transfer without depositing excess adhesive. Use the minimum amount of squeegee pressure that achieves complete ink release. Higher squeegee pressure will force excess adhesive beyond the image area only to create a sticky screen

DRYING / CURING

Water- and solvent-based PSAs can be dried on racks at room temperature, in convection dryers, or in IR dryers. The time required for drying depends on the thickness of the adhesive deposit, the drying temperature, air movement and type of substrate.

The following table demonstrates how the same adhesive printed through various meshes requires different drying times.

Mesh count (threads/in)	54T	86 T	110T	195T
Drying at 68°F	45 min.	25 min.	20 min.	10 min.
Drying at 158°F	7 min	3.5 min	2.5 min	1.2 min

The adhesive must be completely dry before you apply the liner because residual solvent in the adhesive may cause lower peel values. Water-based adhesives, which are milky when wet, turn clear when dry. Solvent-based adhesives require a different approach because the wet and dry appearance is about the same. When a popsicle stick touches then is removed from the adhesive surface, fine strings or hairs indicate that it is still wet. Normal tack and the absence of stringing indicate properly dried adhesive. A production test run followed by a peel test is always a good way to ensure the adhesive is dry.

When drying PSAs with a convection dryer, the maximum dryer temperature should be 158-176°F (70-80°C) with good air movement. Air movement is important not only to prevent a concentration of solvent vapors, but also because it helps keep the substrate and adhesive temperature down. If the temperature is too high, the substrate's protective masking film may bond to the substrate face. High temperature may also damage the additives that protect the adhesive from exposure to oxygen and UV radiation. While the damaged adhesive may remain flexible, it will provide lower tack than expected. The adhesive will eventually become dry and then brittle. To prevent problems associated with drying, it is always best to check the manufacturer's spec sheet for drying recommendations before you begin printing.

With IR dryers, as with convection dryers, there has to be sufficient hot-air movement to remove solvent and moisture vapors while preventing overheating of the adhesive

With UV curable adhesives, follow the manufacturer's recommendations for curing. This will involve not only proper wattage, distance and time through the unit, but also proper maintenance of the uv lamps. Undercured adhesive will have low peel strength and low temperature resistance; while overcured film has little or no tack.

LAMINATION OR LINER APPLICATION

After drying or curing, one should quickly laminate the adhesive decal or overlay to the second substrate or apply a release liner. If using a liner, apply it quickly enough to prevent dust and contaminants from reaching the adhesive. The liner should also provide a strong enough bond to remain affixed to the adhesive throughout die-cutting and additional processing steps.

After the liner is applied, you may want to store the printed piece. Choosing a cool dark area free of uv light is particularly important when you plan to store rubber-based or other PSAs with limited uv resistance. Storing conditions that include cool temperatures of approximately 60-68°F (15.6-20°C), and low humidity are suitable for many adhesives. Make sure to follow the manufacturer's recommendations about storing times, temperatures, humidity levels, and related considerations.

The manufacturer may also recommend against high stacking of printed pieces because stack pressure may reduce the DFT and cause the adhesive to flow over the substrate edges. While this may not occur with all adhesives, it certainly happens with the softer ones. The manufacturer can help you determine safe stack heights.

DIE-CUTTING

Unlike laminating films which must be diecut then hand positioned, printable PSAs are selectively applied at a distance of 0.5 - 1 mm from the diecutting line to avoid gumming

ADHERING THE PRINTED PART

When it is time to apply the graphic laden decal/overlay, one can improve the bond to the second substrate with the following measures:

1. **Make sure the second substrate is free of dust, oil, or anything which may reduce adhesion such as residual mold release agents. Wiping the application surface with alcohol should sufficiently remove destructive contaminants.**
2. **Use application temperatures between: 68-140°F (20-60°C) for optimum adhesion.**
3. **Apply pressure (approx. 3-4 bar) to the part/decals with a heated silicone rubber pad 104-122°F (40-50°C).**
4. **Prevent air bubbles by carefully rolling the piece into position, while stretching the substrate.**
5. **When applying the decal to a molded part, the application should be smooth and devoid of all burrs and spur marks.**
6. **Covering a sufficient amount of surface area with adhesive relative to the total surface area.**

CONCLUSION

Screen printable PSAs are more than just adhesives. They can provide a wide variety of performance based on how you apply them. While capable of providing the strength and permanence needed by the automotive industry they can also provide temporary adhesion desired for weekly POP displays. Though they might not be recommended in every application where tapes are used, they are certainly qualified for use in many of the indoor applications.

These versatile adhesives can save you time and money where you need it most: lower material costs without value added, labor intensive processing.

Why not test a PSA for your next adhesive challenge. With a little care, it is easy to produce successful results with selectively applied PSAs.