Design Guidelines

TABLE OF CONTENTS

An overlay consists of a base material that is second surface printed (on the back side) to protect the inks. It is then laminated or coated with a pressure sensitive adhesive. Each particular application must be evaluated prior to choosing an overlay material. What has worked in the past may not be the best choice for a similar, yet different, application. The two main criteria used in choosing an overlay material are abrasion and solvent resistance. Other criteria include actuation life for keypad applications, UV resistance for outdoor applications, and available thicknesses.

Currently, the vast majority of overlays are manufactured from either polycarbonate or polyester. Polycarbonate has been the most popular choice of screen printers for years because of its fabrication ease. However, while polyester is still not as forgiving as polycarbonate during fabrication, its superior life expectancy in many applications has made it a necessary alternative. In the following sections, first polycarbonate and then polyester will be examined in detail as we explain the advantages and disadvantages of each material. Later we will discuss the potential uses of two additional specialty films: coblend and copolyester.

Polycarbonate

Graphics grade polycarbonate is available in thicknesses ranging from .005" to .030" with extreme clarity and a wide variety of textures and matte finishes. UV resistant, flame-retardant, and hard-coated films are also available. This flexibility is one of the main advantages of polycarbonate film. The hard-coated versions provide very good abrasion resistance and increased solvent resistance, which is important, considering the fact that raw polycarbonate can scratch easily and its solvent resistance is rather limited. Some very mild solvents can cause damage over time and more aggressive solvents can destroy polycarbonate very quickly (see chart).

Solvent	**Polycarbonate Resistance (24 hours exposure to DIN 42 115 Pt-2)**
Methyl ethyl ketone	Failed
Cyclohexanone	Failed
Acetone	Failed
Ethanol	Passed
Benzyl alcohol	Failed
Genklene (1,1,1 Trichlorethane)	Failed
Perklone (Perchlorethylene)	Failed
Trichlorethylene	Failed
Methylene Chloride	Failed
Diethyl ether	Failed
Toluene	Failed
Xylene	Failed
Gasoline	Passed (Failed after 10 days)
Diesel oil	Passed
Dimethylformamide	Failed
Nitric acid <10%	Passed
Sodium Hydroxide <10%	Passed
Turpentine	Passed
Ethyl acetate	Failed

As mentioned, hard coated polycarbonate films are available that can provide increased abrasion and solvent resistance. An overlay designed to incorporate a non-textured, optically clear window should always utilize a hard coated product to help prevent scratches. The hard coated products can be selectively textured (screen printing the texture and leaving the window area unprinted) providing even more resistance to marring and fingerprints, and yet maintaining an optically clear viewing area that would still be hard coated. Although a hard coat will provide increased solvent resistance compared to raw polycarbonate, the number of potential solvents and the difference in hard coats

available, warrant a discussion early in the design stage, in regards to any specific solvent resistance requirements.

Polycarbonate is relatively stable up to 300 degrees F. However, any long-term exposure to temperatures exceeding 185 degrees F can lead to an increase in haze and yellowness. Low temperatures have little effect on polycarbonate film, which remains ductile at temperatures down to at least –150 degrees F. Polycarbonate is easily formed and is the film of choice for many in-mold decorating (IMD) applications.

Embossing puts undue stress on polycarbonate film and the continual flexing of the material that occurs over the lifetime of an embossed overlay can cause stress fractures and eventually a breakdown of the film in the embossed area. This is true of a hard coated product as well. Once the hard coat is fractured, the overlay becomes more susceptible to the solvents it was designed to resist, and a breakdown is imminent. An embossed polycarbonate has a much shorter actuation life than a polyester overlay. Depending on a number of variables, (switch travel, actuation force, overlay thickness, emboss height, type of switch), an embossed polycarbonate overlay could last from as little as a few hundred to 100,000 actuations or more (see "***EMBOSSING GUIDELINES***" pgs. 8-9).

To summarize, polycarbonate is an excellent choice for IMD or less demanding overlay applications. Its wide thickness range and variety of textures and finishes provide flexibility for a designer to find a "fit" for almost any application. In fact, the most popular overlay material is a pre-textured, or "velvet" polycarbonate. The velvet texture provides an antiglare and scuff resistant finish for easy handling during manufacturing, fabrication, and application, making it a logical choice for a variety of overlay applications.

Polyester

Polyester is available in optically clear grades up to .010". Above this, and the film begins to turn milky white. This can limit the use of polyester in some applications. For example, handling problems can occur on larger overlays, as the thinner material is more prone to denting.

Polyester, though somewhat harder than polycarbonate, can still scratch easily and is available with a variety of hard coat finishes to protect the surface from scratches. They include clear, a variety of anti-glare finishes, and textured products. UV resistant films are also available.

Polyester films have inherently higher chemical and mechanical resistance properties than that of polycarbonate and can survive long term temperature exposure up to 248 degrees F. Its solvent resistance renders it virtually unaffected by all commercially used solvents (see chart). Due to its inherent strength, an embossed polyester overlay does not suffer fatigue in use and has 20 times the flex life of polycarbonate. Actuations in excess of five million have been reached in testing. If embossed properly, following specified guidelines, actuations in excess of one million are routine. This inherent strength, however, does make polyester difficult to form to any significant heights, depths, or draws.

Solvent	**Polyester Resistance (24 hours exposure to DIN 42 115 Pt-2)**
Methyl ethyl ketone	Passed
Cyclohexanone	Passed
Acetone	Passed
Ethanol	Passed
Benzyl alcohol	Passed
Genklene (1,1,1 Trichlorethane)	Passed
Perklone (Perchlorethylene)	Passed
Trichlorethylene	Passed
Methylene Chloride	Failed
Diethyl ether	Passed
Toluene	Passed
Xylene	Passed
Gasoline	Passed
Diesel oil	Passed
Dimethylformamide	Passed
Nitric acid <10%	Passed
Sodium Hydroxide <10%	Passed
Turpentine	Passed
Ethyl acetate	Passed

In summary, polyester films are significantly "tougher" than polycarbonate films and work well in more demanding applications, such as a membrane switch application or where the overlay will be subjected to harsh chemicals. Its limited thickness range, however, can limit its application uses.

Overall, the cost difference between polycarbonate and polyester film can be a factor. Hard coated versions of both are more expensive than uncoated. However, because of the way polyester is produced, any pre-texturing has to be done during the hard coating process, making the textured polyesters substantially higher priced than their polycarbonate counterparts. In general, polycarbonates are still somewhat lower in price than polyesters, but given the overall cost of product failures, the main concern has to be the performance of the overlay in the field.

Specialty Films

Coblend

Coblend film is an extruded material based on a polymer blend. The properties of this film are between a polycarbonate and a thermoplastic polyester.

The polycarbonate properties of the film allow for easy forming. While the polyester properties allow embossed switches to have a service life of over 3 million cycles, these same properties also improve the short-term solvent resistance when compared to polycarbonate.

Due to the polyester component, the coblend film is not available as a gloss/gloss film. The polyester component crystallizes causing the haze of the film to increase and the color of the film to be bluish. The product is available in .007" and .010" textured versions only.

The pricing for this product is between that of textured polycarbonate and textured polyester, making it a low cost alternative to textured polyester for membrane switch applications. It should also be considered where improved solvent resistance over polycarbonate is required.

Copolyester

Copolyester films are available in gloss/gloss and textured versions in .007" to .020" thicknesses. They provide a chemical resistance similar to polycarbonate and a heat resistance up to 212 degrees F. Copolyester is an excellent choice as a low cost alternative to polycarbonate.

LABEL CONSTRUCTION SELECTION

As with overlay materials, each particular application must be evaluated against certain criteria before choosing a label construction. Most label constructions utilize a base material that includes a thin layer of pressure sensitive adhesive already applied to the substrate. The surface being applied to, and the surface shape and texture, is a determining factor in most applications. Certain surfaces, depending on their surface energy, require different types of adhesive (see ***"ADHESIVE CHARACTERISTICS* – Surface Energy"** pgs. 6-7). Since all pressure sensitive films are available with the different adhesive types, this section will focus on the differences between vinyl and polyester as base materials in your label construction.

Vinyl

Vinyls are used mainly for caution and warning type labels, identification labels, "bumper sticker" and other similar type products, and as a low cost logo label alternative. Vinyl labels are less solvent resistant then polyester and first surface printed. A polyester over-lamination can provide added durability and, if using a matte polyester, an antiglare finish.

Vinyl is a very flexible material easily distinguished by its smell, and how easily it can be stretched. Because of its conformability, vinyl is perfect for uneven, curved, or slightly textured surfaces. However, because it is less dimensionally stable than polyester, and can shrink by as much as .015" over time, vinyl should not be used where an exposed edge would become a problem. Rigid or "hard" vinyls are somewhat more dimensionally stable, but can still shrink, especially at elevated temperatures. The normal temperature range for vinyl labels is from –40 to 176 degrees F. Some premium vinyls have an upper limit of 225 degrees F.

Vinyls are available in a variety of colors, the most common being white, and clear. The white background means one less printed color and is a huge factor in making vinyl labels an economical choice for most applications.

Polyester

Polyester is a common base material for model and serial number, identification, and caution and warning labels. Polyester is dimensionally stable and has excellent solvent resistance and is often used as an over-lamination to provide added durability to other labeling systems. Because it is so stable, it will not stretch like vinyl films and should not be used where conformability is required. On even slightly textured surfaces, extra coatings of adhesive are needed to achieve intimate contact with the surface and to avoid "orange peel." Polyester, besides being more dimensionally stable than vinyl, also has a much higher upper temperature limit. The normal temperature range is –40 to 302 degrees F.

Polyester is also available in a variety of colors, with the most popular versions being white, clear or silver. The silver version is available in bright, bright polished, or matte and is commonly used as a low cost alternative to a metal nameplate.

The cost difference between intermediate vinyls and polyester is small. Promotional and intermediate vinyls (six months to two years outdoor durability) tend to be slightly less expensive. Premium vinyls (five to seven years outdoor durability), however, can be quite expensive when compared to polyester.

PRODUCT LIFE EXPECTANCY

Life expectancy of a product is affected by its end use and environment, and by the material, adhesive, and colors chosen. Generally, a decorative overlay has unlimited indoor life. Polycarbonate, especially when embossed, is less resistant to chemicals than polyester. The presence of certain cleaning chemicals and other solvents can have a major impact on the life of a polycarbonate overlay and exposure should be taken into consideration for each application.

A keypad life would be dependent on the number of actuations and whether or not the pads are to be embossed. Polyester has more than 20 times the flex life of polycarbonate and is ideally suited for highly active keypad overlays. A polyester overlay can exceed 10,000,000 actuations unembossed and embossed keypad overlays will routinely exceed 1,000,000 actuations. Unembossed polycarbonate keys may last 500,000 or more actuations, while embossed keys, depending on a number of factors, may last as little as 500 to as many as 100,000 actuations (see ***"EMBOSSING GUIDELINES"*** pgs. 8-9).

Neither polycarbonate nor polyester overlays are recommended for extended outdoor use. The materials will yellow, chalk, or become brittle. The standard clear and velvet textured versions of GE Lexan polycarbonate have UV stabilizers which allow for intermittent exposure and limited outdoor use. There are UV resistant versions of both materials now available, at a higher cost, that can be used for long-term outdoor exposures.

Most pressure sensitive label products are warranted for anywhere from six months to two years outdoor life. However, with material changes (premium cast vinyls) or UV resistant laminations (Acrylar, Tedlar), a label product life could easily be extended to five to seven years or longer.

For outdoor applications, non-fading colors should be considered whenever extended life is needed. Fluorescent colors can fade in three to six months. Certain pigmented colors can fade in direct sunlight in a matter of two to three years. Colorfast, or non-fading colors should last three to five years without protection. A clear coat or a standard polyester overlaminate may add six months to one year, and a UV resistant over-laminate (Acrylar, Tedlar) should provide several additional years of fade resistance to any color. Humidity and water have little effect on an overlay or label once applied. If salt spray or dust is a concern, a second surface printed or an over-laminated product should be used.

ADHESIVE CHARACTERISTICS

It is important to realize that all adhesives are not the same. What has worked in a previous application may not work, or may not be cost effective, in a new application if any one of several factors has changed. These factors will be discussed and adhesive recommendations will be made. The recommendations pertain to overlay applications and will specify 3M transfer adhesives. Regardless of the adhesive chosen, surface contact is fundamental to any adhesive performance. To maximize adhesive contact on a surface:

- It must be dry and free of contaminants. Whenever possible, it is recommended that a prepping of the surface be done with isopropyl alcohol.
- Firm pressure must be applied to increase the flow and contact of the adhesive with the substrate.
- Time and temperature will increase the surface contact and adhesion values.

Surface Energy

Adhesion is the molecular force of attraction between unlike materials. The strength of attraction is determined by the surface energy of the material and the chemical make-up of the adhesive (i.e., acrylic, modified acrylic, rubber based, etc.). The higher the surface energy, the greater molecular attraction. The lower the surface energy, the weaker the attractive forces. Greater molecular attraction results in increased contact between an adhesive and substrate. In other words, on a high surface energy material, the adhesive can flow (or "wetout") to assure a stronger bond.

Consider an automobile that has not been waxed for a long time. When water contacts the surface, it spreads in large puddles. The un-waxed surface exhibits high surface energy – the molecular attraction allows the water to flow. In comparison, water beads up into small spheres on a freshly waxed car. It is an example of low surface energy – the liquid (or adhesive) does not flow out. When considering adhesives for an overlay application, first determine the surface to be applied to and identify the surface energy as having high or low surface energy. Surface energy is measured by dynes per centimeter. The following chart lists the dyne levels of some common substrates.

Surface Energy Chart

Metals	**Dynes/cm**
Copper	1103
Aluminum	840
Zinc	753
Stainless Steel	700 – 1100
Tin	526
Lead	458
Glass	250 – 500
High Surface Energy Plastic	
Kapton	50
Phenolic	47
Nylon	46
Alkyd Enamel	45
Polyester	43
Epoxy Paint	43
Polyurethane Paint	43
ABS	42
Polycarbonate	42
PVC	39
Noryl	38
Acrylic	38
Polane Paint	38
Low Surface Energy Plastics	
PVA	37
Polystyrene	36
Acetal	36
EVA	33
Polyethylene	31
Polypropylene	29
Tedlar	28
Teflon	18

In addition to those listed, powder coat paints tend to exhibit a low surface energy due to the high level of flow additives used. Because of the many formulations of powder coat paint, and several of the surfaces listed, testing should be done to ensure proper bond strength between adhesive and substrate.

Firm acrylic adhesives tend to have excellent cohesive strength values and work very well on metals and high surface energy substrates. 3M families #200MP and #220 should be specified for overlay applications under these situations. Modified acrylic adhesives have better flow characteristics and work extremely well on low surface energy and other hard to adhere to surface. The firmer acrylic adhesives will not readily adhere to these substrates. 3M #300LSE is specifically designed for such applications and should be considered.

Surface Shape and Texture

A flat surface with little or no texture requires only a thin coating of adhesive. The standard adhesive coat weight on most pressure sensitive films is sufficient*. However, any irregularities in the surface may require added adhesive, or a change in construction from a pressure sensitive film to an overlay to assure a good bond or to hide the anomalies. A textured surface demands a heavier coating of adhesive to assure complete and intimate contact with the entire surface and not just the "peaks". Nearly all 3M adhesives are available in a .005" version specifically designed for textured surfaces.

Curved surfaces require a somewhat flexible material and an adhesive with an excellent internal strength. A free flowing adhesive with lower cohesive values can have a tendency to "split" and lift from a curved surface.

*Standard pressure sensitive films carry adhesives that are .0007" - .001" thick and meant only for smooth high surface energy applications. However, different types and thicknesses of adhesives can be custom coated for any foreseeable application. Please be sure to consider the criteria mentioned in this section when designing a label utilizing a pressure sensitive film. In some instances a removable or re-positionable adhesive is desired. Please be sure to include this information on your drawing so the correct pressure sensitive film product can be incorporated into your label construction.

Initial Bond

All permanent adhesives are designed to have a high ultimate bond when used as specified on the correct surface. However, the more free flowing adhesives have a higher initial bond strength and feel "sticky." These adhesives bond very quickly and once applied, cannot usually be removed without damaging the overlay or the adhesive layer. This initial bond strength would be important in applications that require immediate handling (assembly line setting), or where the surface cannot be properly cleaned prior to applying the overlay (in the absence of prepping, thorough testing should be completed).

The firmer adhesives have less tack and in some applications can be repositioned without damaging the overlay, but may not have a sufficient initial bond to withstand immediate handling.

Environmental Concerns

The firmer adhesives tend to have better resistance to temperature and humidity, UV light, and chemicals. The firmer adhesives, for example, have upper temperature limits of 350 – 450 degrees F, while the more free flowing adhesives are limited to 250 – 300 degrees F. However, once applied, adhesives will perform very well under all the conditions mentioned.

Rubber-based adhesives would be the exception. They are used on many low cost, pressure sensitive films and have excellent adhesion to a variety of surfaces, including low surface energy substrates. They do, however, have poor UV resistance and will yellow over time. They can also fail where exposed to water or high humidity, and provide little resistance to chemicals. They should only be specified for short-term (less than one year) outdoor, or indoor applications.

ADHESIVE RECOMMENDATIONS

The following chart can be used as a guide for specifying transfer adhesives in overlay applications.

3M Family	Application	.002"	.0035"*	.005"*
200 MP	Individually supplied with or without a split liner	3M 467MP	-	3M 468MP
	Individually die cut with a tab	3M 9667MP	-	3M 9668MP
	Sheet form, kiss cut to liner	3M 9667MP	-	3M 9668MP
	Selective adhesive areas (windows, keypads, etc.)	3M 7962MP	-	3M 7965MP

Excellent adhesion to metals and high surface energy substrates. Temperature resistant to 400 degrees F. Excellent shear strength provides very good adhesion to curved surfaces. It's extremely smooth which allows it to be used in backlit applications. Firm in nature, it can provide some level of repositionability.

220	Individually supplied with or without a split liner	3M 9502	-	3M 9505
	Individually die cut with a tab	3M 9502HL	-	3M 9505HL
	Sheet form, kiss cut to liner	3M 9502HL	-	3M 9505HL
	Selective adhesive areas (windows, keypads, etc.)	3M 9552HL	-	3M 9555HL

An economical version of the 200 MP family of adhesives with many of the same characteristics. Temperature resistant to 350 degrees F.

300LSE	Individually supplied without a split liner**	3M 9471LE	3M 9453LE	3M 9472LE
	Individually die cut with a tab	3M 9671LE	3M 9653LE	3M 9672LE
	Sheet form, kiss cut to liner	3M 9671LE	3M 9653LE	3M 9672LE
	Selective adhesive areas (windows, keypads, etc.)	3M 8132LE	3M 8153LE	-

Very good adhesive to low surface energy substrates. Temperature resistant to 250 degrees F. Free flowing adhesive provides excellent initial bond strength.

*Increased thickness designed for use on textured surface.
**We do not recommend a split liner because of the free flowing nature of this adhesive.

Embossing Guidelines

Embossing could be defined as "forming raised areas to provide functional and/or aesthetic features to an overlay or label design." Functionally, embossing is incorporated into the graphic overlay for switch assemblies to provide a tactile feel. Other functional purposes for embossing include raised LED window areas for earlier detection when viewed from the side, and Braille signage. Aesthetically, embossing could be performed on logos or text to create three-dimensional effects for overlays or label constructions. The discussion to follow will focus on the guidelines that should be followed when embossing a graphic overlay for switch assemblies.

As previously discussed, polycarbonate and polyester are the two most common materials chosen for overlay applications. In tests, embossed polyester has more than 20 times the flex life of polycarbonate and much better tactile response. This performance is due to the superior mechanical properties of polyester film. This high strength necessitates the use of tooling and processes different to those of polycarbonate. These tooling and process differences will not be discussed here but are practiced at DuraTech and could be explained in detail if desired.

Although the tooling and processes used to emboss polyester are different from polycarbonate, the guidelines used to design a typical emboss are quite similar. The following design guidelines for embossed parts will help to minimize stress and maximize key life in membrane switch applications utilizing either polyester or polycarbonate as the overlay material.

Material Thickness
Thicknesses up to .010" can be readily embossed, and polycarbonate films up to .020" can be embossed in certain configurations. For thicknesses greater than .020" thermoforming or hydro forming should be used.

Embossed Width
The width of a rail (ridge, rim) emboss should be at least five times the material thickness. The minimum rail width for a .010" thick material would be .050". If adhesive and liner are included behind the rail, their thickness must be included when determining the rail thickness.

Note: Line widths less than the recommended thickness can result in warping or buckling of the overlay.

Embossed Height
The height of an embossed area should be no greater than 1.5 times the material thickness for polycarbonate, or 1 times the material thickness for polyester. Polyester's extraordinary strength makes it difficult to maintain a height greater than 1 times the material thickness.

Note: Excessive emboss heights increase the risk of material failure. Greater embossed heights can be reached with polycarbonate, but are not recommended for membrane switch applications.

Embossed Spacing
A minimum space of .187" should be held between embossed areas and internal cut outs or the die cut edge.

Note: Typically the number of embossed areas is not a concern if the proper spacing and embossing criteria are observed.

Embossed Configurations
The inside and outside corners, and any intersecting lines, shall maintain a minimum radius of .060". The inside and outside corners should use the same center for the radius. The radius at the end of any line will be a function of the line width.

Note: Sharp corners increase the risk of material failure.

Embossing Tolerances
The standard registration of emboss to printing is +/- .015". Thought should be given to designing the embossed area intentionally smaller than the printed key by .015" on all sides. This prevents the emboss from straying off the key area. Standard registration of emboss to internal cut outs or the die cut edge is +/- .020". The emboss height will be held to within +/- .005" with a minimum emboss height of .003".

In summary, embossing can add a great deal to the functionality and aesthetic quality of an overlay or label design. However, when working with polycarbonate films, it is important to realize that embossing raised areas for membrane switch keys will significantly reduce the life of the overlay. Since switch size and travel, film thickness, embossed height, and working environment can all be factors, it is recommended that life testing be performed on any project utilizing polycarbonate where more than a few thousand actuations will be necessary.

Forming
DuraTech has the capability to form certain plastics for use in in-mold decorated applications and for other 3D applications.

Our process uses heat and pressure to create consistently registered formed appliqués . Because of the variation from design to design, it is difficult to define standard forming tolerances. Most graphics should fall in the +/- .030" range (or better). Polycarbonate is the material of choice for this process but other materials are available.

Below is a table of forming guidelines and recommendations.

DuraTech Industries Forming Guidelines	
Description	**Comments**
Undercuts	Not possible
Draft Angles, Perimeter of part	3° minimum, 5° preferred
Draft Angles, Internal holes	1.5° minimum, 2° preferred
Inside Radii (inside of bend)	1x material thickness
Outside Radii (outside of bend)	2x material thickness
Part Corner Radii	~5x material thickness
Spacing (between pockets)	.25" flat area between "pockets"
Spacing (between form cores)	3x the depth of draw ~ up to 4-5x for some hard coated products
Free Space (perimeter of nest)	3x the depth of draw ~ up to 4-5x for some hard coated products
Maximum Draw	1.38"
Minimum Draw	~.2"
Maximum Sheet Size	18" x 21`" (current in-house capability but outsourcing is available)
Maximum Form Area	~ 14" x 17" at 1" draw. Exact max depends on draw depth and geometry. • Certain geometrics may affect dimensions given. Please consult DTI on each project that may fall close to dimensions listed above.

In-Mold Decorating (IMD) Recommended Material Specification Guidelines

- Generally speaking the thinner the material the less chance of gate wash (less mechanical shear).*
- Thicker materials may be required to prevent "oil canning" or sagging of material over open areas (cutouts in molded housing but not appliqué).
- Applique material used should be compatible with resin—call DTI with any questions.
- 15 mil material is recommended for draws greater than .5", and 20 mil for draws greater than 1".
- Low stress materials (8A13E, T2F, etc.) should be used where graphic registration is critical and must be repeatable.
- Textured materials (8A13F, 8B35F) are much less expensive than hard coated options.

*Wall thicknesses should be kept to .100" minimum if possible (or at least 10x graphic thickness). The more consistent the housing wall thickness supporting the graphic the better.

Resin Recommended Guidelines

- Resin needs to be compatible with appliqué material.
- Whenever possible, a high flow resin should be used.
- Glass filled resins should be avoided if at all possible.

DESIGN ISSUES

This section will discuss issues and concerns that need to be addressed in the early design stage of a project. By assuring that a quality part can be produced using the screen printing process, potential delays and misunderstandings, due to unrealistic expectations, can be avoided. The variation in materials, equipment, tools, processes and techniques used in screen printing is staggering. Even with incoming inspection, verification of printing equipment, tooling accuracy, process control, and variation, to some degree, will be present in all screen printed work. To fully understand the issues requires a basic knowledge of the screen printing process.

Registration

Screen printing involves the forcing of inks onto a substrate through a highly tensioned mesh fabric. Customer art is color separated and screens are "shot" for each color. The screen has a negative image developed into the fabric allowing ink to flow through in desired areas only. The registration of each color pass to a previously screened color is checked during press set up but is subject to a number of variables including: the accuracy of the original art and equipment used to color separate, output, and step up the artwork films; the tension level of the stretched fabric used to produce the screens; the press set up, including off contact, viscosity of the ink and resulting squeegee pressure; the accuracy of the person registering the stock running piece and press being used; and the dimensional stability of the substrate being printed. The registration of any embossing (see **"Embossing Guidelines"** pgs. 8-9), die cutting (see **"Tolerances** – *Graphics to Die Cutting"* pg. 12), and hand applying of selective adhesives bring additional variables into the mix. Multicolor jobs designed without regard to registration will increase cost and affect the overall quality of the part.

Color and Opacity

The color and opacity of the ink are determined by how much ink is forced through the mesh and onto the substrate. The amount of ink deposited onto the substrate is also affected by a number of variables including: emulsion thickness; size of the openings in the mesh fabric and fabric material; durometer, size, and edge profile of the squeegee; squeegee angle and pressure; squeegee stroke length and speed; floor bar type, speed, and pressure; and substrate being printed. In most cases, screen printers will print in an order that will allow them to use darker colors to "hide" any bleeding (overlapping of colors). Designing parts without consideration given to the opacity and bleeding of the colors chosen can lead to undesirable "shadows".

Printability

As mentioned, the opacity of the ink is affected by the size of the openings in the mesh. These openings also determine the printability of small text, thin borders, intricate graphics, and the quality of all graphic edges. Legibility and print quality must be considered when designing a screen printed part.

DESIGN RECOMMENDATIONS

Following is a list of recommendations, which when followed, will help reduce cost and enhance the aesthetic quality of the finished part.

Critical Placement
Window and keypad placements should be created by one color. This can be achieved by making all key backgrounds the same color as any window outlines or by outlining all key and windows with the same color.

Note: More colors can create the placement of windows or keys, however the +/- .015" graphic to die cutting tolerance can only be held for one color that is deemed the most critical. Color to color registration would be held to +/- .020".

Borders

- Light color borders should be avoided. If darker colors are printed first, chances are the light color border will be created by two darker colors. In this case the border thickness could vary by up to .040" (+/- .020"). This varying thickness may be unacceptable. If the light color border is printed first, opacity and "hiding" power of the color become an issue. The color desired may be impossible to achieve because subsequent darker layers of ink may "draw down" a lighter, brighter color. Also, the light border may not be able to hide shadows of any darker colors bleeding behind it and the border may appear to be two or three different shades.
  Note: If a light color border is desired, thought should be given to the other colors being used on the overlay.

- A border separating two colors should be at least .020", and preferably .030" thick. The two colors will be designed to split any border thickness allowing a certain amount of "play" during the screening process. The bleed is needed because of the registration issues discussed earlier.
  Note: Drop shadows or outlines should also be at least .020" thick. Any thinner and the outlining may disappear or separate from the text due to the color to color registration issues previously discussed.

- Borders outlining interior cutouts or the perimeter of a part should be avoided. The border thickness may appear to be uneven, especially on thin borders.
  Note: If a border is used, it should be at least .030". The thicker the better. A .015" variance in thickness is much more noticeable on a .030" border than on a .060" or a .090" border.

Kiss Touch Registration

- Kiss touch colors (colors that "bump" or "butt" up to each other) should be avoided when neither color can effectively hide the bleed needed to keep the colors from separating during printing.
  Note: A black border is an alternative under this circumstance.

- The kiss touch design of a selective texture to a window edge will result in, on two sides only, a "sliver" of un-textured background being visible. Glossy black "slivers" are very apparent. The selective texture should be designed to bleed completely into, or away from, the window edge so the appearance is consistent.
  Note: DuraTech will bleed the texture in to the window by .010" on all sides, unless otherwise specified.

Printability

- Small text, serifs, and thin lines should be avoided whenever possible. The minimum recommended point size is 5 pt. and lines should be at least .010" in width to ensure consistent print quality.
  Note: Smaller text or line weights could be used but will result in inconsistent print quality. Portions of a letter or line may get thinner, lighter in color, and possibly disappear.

- 100% to 0% color fades are not possible. The dots used will become unprintable at the very high and low end of the scale. A 90% to 10% scale should be used to create the fade.
  Note: Four color process and dot gradients need to be discussed on a job-by-job basis. Screen printing requires the use of larger dots. This can effect the appearance of an image originally output under different conditions.

Opacity

- Light outlines of backlit areas should be avoided. Light will shine through ink layers that are not completely opaque, causing "halos" to appear around any LED windows or backlit graphics.
  Note: Shadows (opaquing layers) can be added to diminish the "halo" effect– at an added cost. Any shadow will be made slightly larger (.010" - .015") because of registration issues. This will still result in a very slight, somewhat noticeable "halo" around the window or graphic.

- Depending on the color of the surface being applied to, a light background may not be advisable. The background color may appear to be different after the part is applied. Also, any anomalies in the surface being applied to may be visible through a light background color.
  Note: Multiple passes of ink (opaquing layers) can be added to overcome any of the above problems – at an added cost.

CAPABILITIES

DuraTech is a sheet-fed screen printer of decorative overlays and labels, on thin gauge plastic, aluminum, and pressure sensitive materials. Since we are a sheet-fed printer, we do not manufacture roll labels, print on textiles, etch or stamp in-house. Instead we have partnerships developed with several key strategic suppliers to handle all of your nameplate and labeling requirements. The following sections describe current process and equipment capabilities for parts produced in-house.

Tolerances

The most commonly overlooked and perhaps misunderstood area in design are the tolerances associated with the printing and cutting of an overlay or label. Care should be taken to avoid overspecing a part – by not adjusting tolerance levels on blueprints used for other commodities, by not considering the registration issues associated with the screen printing of multiple colors (see ***"DESIGN ISSUES"*** – ***Registration"*** pg. 11), the effect of unstable materials, or the accumulating of tolerances. Generally, the tighter the tolerances, the higher the initial tooling costs, and the larger the fallout percentages in the running of the part. These higher costs may be avoided by following standard tolerances for the screen printing industry.

Die Cutting

+/-. 020" – Economy steel rule die (can be jig cut or laser burned)

+/- .015" – Standard steel rule die (can be jig cut or laser burned)

+/- .010" – Tight tolerance steel rule die (laser burned—generally used for mated parts or parts that fit a recess)

+/- .005" – Hard tool (generally used for extremely tight tolerance or long running projects)

+/-.010" - Electronic knife plotter (generally used for short runs. As material thickness increases (above .015") tolerances may increase to +/- .020" or greater.

Steel rule dies are an excellent low cost alternative to hard tooling for thin gauge plastics (generally .030" or less) and pressure sensitive films. They do however, have a limited life when compared to hard tooling and therefore are considered ***temporary tooling*.*** Steel rule dies consist of a razor sharp steel rule embedded into high quality maple or birch plywood. Due to a number of variables, the steel rule edge will eventually dull and need to be replaced. As the material thickness increases above .010", so does the maintenance of the die. Also, a die used to cut a pressure sensitive vinyl or a soft plastic such as polycarbonate, may require to be re-ruled or rebuilt to cut a harder polyester material or a brittle styrene. The cutting action (the steel rule tip displaces the material as it cuts and "crushes" it against the bed of the die cutting press) can also lead to crimping and burred edges. The severity will again depend on the type and thickness of the material and the proximity of any cut outs to each other or the perimeter of the part. (see ***"Maximum Size and Cutting Restrictions"*** pg 15).

Hard tooling will provide a tighter tolerance and a much longer cutting life compared to steel rule dies. It is safe to say that for most applications, a hard tool will last for the life of a project. The "scissor-like" cutting action produced from the male/female design provides a clean cut and helps to deter crimping. As expected, the improved quality, tighter tolerance, and longer life have a price tag. A simple rectangle configuration hard tool can easily cost $2,500, while a multi-cutout configuration could approach $10,000.

*Because of the number of variables, it is difficult to determine an actual life for a steel rule die. The variables include the amount of rule in the die, the type and thickness of the material being cut, the press condition, and the die set up. DuraTech will store all steel rule dies and maintain (re-rule or re-build) at cost and bill accordingly. Since steel rule dies are considered temporary tooling, they remain the property of DuraTech. Hard tooling remains the property of the customer. Hard tools will also be stored at DuraTech and any maintenance costs (sharpenings) will be billed accordingly.

Graphics to Die Cutting

+/- .015" – Industry standard

See **"*DESIGN ISSUES* – Registration"** pg. 11, and **"*DESIGN RECOMMENDATIONS* – Critical Placement"** pg. 10—11 for further information.

Printed Graphics

+/- .010" - Printed graphics to graphics when registration is created by one color

+/- .020" - Printed graphics to graphics when registration is created by more than one color

See **"*DESIGN ISSUES* – Registration"** pg. 11, and **"*DESIGN RECOMMENDATIONS* – Critical Placement, Borders,** and **Kiss Touch Registration"** pg. 10—11 for further information.

Artwork

DuraTech has a fully computerized in-house art facility. We work off of sketches, blueprints, samples or customer supplied computer art.

Artwork can be received electronically through e-mail at artwork@duratech.com or on a CD

When sending computer art; fonts, linked images or supportive files should also be included. Blueprints or some documentation of colors, typestyles and location dimensions of windows, cutouts and any other critical areas should be specified.

A program list of all file types accepted is available. This is updated on a regular basis as new versions are issued. If your software is not listed, please contact DuraTech. We may be able to work with your file as is, or we will purchase the software if necessary.

We provide proofs and/or DuraTech blueprints upon request.

COLOR MATCHING

DuraTech utilizes the latest in color matching equipment. A spectraphotometer is used to aid in the formulating and color checking of day-lit colors, while a separate piece of equipment, a spectrascan, is used to read backlit colors. This equipment assures that the color approved will be consistent, not only throughout a production run, but from run to run, and across your entire line of parts (on identical materials and finishes*).

For any colors other than black or white, a chip or specific call out (Pantone Matching System or PMS, Federal Standard, ANSI, etc.) must be given before we can proceed. Standard colors will be used for black and white unless otherwise indicated. Standards may be used for other colors as well and should be considered whenever possible. Where the difference in colors may be less noticeable, the added expense to achieve a custom color could be avoided. A custom color requires original formulation time, remixing of the inks to within acceptable tolerance levels prior to each order, and on-line color checking to ensure the color remains consistent throughout the run. Standard color chips are available upon request.

*The material and finish will have an effect on the color. A color originally printed first surface on a paper substrate (similar to a PMS book) can look quite different when printed second surface on velvet lexan. In fact, because it is quite subjective and dependent on a number of viewing variables, an exact color match on different substrates may not always be practical. Although this can make color matching difficult and time consuming, DuraTech will submit and resubmit any colors needing approval until the customer is satisfied.

Maximum Size and Cutting Restrictions

The following are recommendations and in some cases depend upon a number of variables. Exceptions may be made after reviewing the exact application. Please call to discuss during the early stages of design.

Size

Maximum: 27" x 36" (Specific registration requirements and certain cutout configurations may cause difficulty and would be addressed at the quoting stage.)

Minimum: ? (More dependent on the legibility requirements of the printing than the cutting. See ***"DESIGN RECOMMENDATIONS* – Printability"** pg. 11.)

Cutting Restrictions: (Steel Rule Tooling)

Radius: .03" (Thick materials may require a larger radius.)
Diameter: .09" (Thicker materials may require the specing of a larger diameter size.)
Spacing of cutouts: 10 times the material thickness

UL/CSA

DuraTech has several UL approved and CSA recognized label and overlay constructions. These constructions are restricted to certain surfaces and temperature ranges. This information needs to be provided during the quotation stage. There are several factors that determine when a label construction needs to meet UL and CSA requirements. Your UL or CSA representative can help you with any questions you may have. Please note any requirements on your drawing including any ANSI or OSHA requirements.

DuraTech is continually adding constructions and parameters (surfaces, temperature ranges, and exposures) to its UL and CSA files. For a detailed listing of our most up-to-date UL/CSA information, please contact your customer service specialist.

DIE CUT FORM AND LINER REMOVAL OPTIONS

Your parts can be provided to you in many different formats. Depending on your assembly process and stocking areas, certain die cut forms or liner removal options may work better than others. If no option is specified during the quoting process, we will quote what is most typical and/or economical for your application and specify this on your quotation.

Individual Die Cut

Parts are individually cut (die cut, shear cut, plotter, laser, blanked, etc.) and packaged in quantities of 25—250 depending on material thickness and part size.

Split Liner

Your parts can have the liner paper split for easy release. The split location may be critical, especially for parts that may be more difficult to apply. If so, please indicate split location on your drawing. Splitting is a very inexpensive operation and should be done for all individually cut pressure sensitive label applications. The thicker overlay materials (≥= .015") would not necessarily require a split liner for easier removal of the backing paper.

Tab

A tab can be added to a part as part of the original tooling. It can also be used to identify the part. The part number can be printed on the tab and then the tab can be used to release the backing paper. A tab is created by "kiss-cutting" to the liner in between the tab and the part. A heavy weight release liner will be necessary to ensure a consistent depth during cutting and a quality release.

Strip/Sheet

Your parts can be "kiss-cut" to the liner and left in a strip or sheet. A heavier weight release liner will be necessary to ensure a quality release. Label sheets are a great way to receive sets of parts. Multiple parts that go on one machine can be received and inventoried as one sheet. At larger quantity levels, strips and sheets can be less expensive than parts supplied individually because some operations are eliminated.

At an additional cost, label sheets can be supplied with the excess label scrap "weeded" away. These "weeded" sheets can make label removal easier and can prevent more free flowing adhesives from rejoining and causing the adhesive to "string and snap back" during removal.

Please indicate if you have restrictions on the overall sheet size during the quoting process.

Pre-spaced

Your parts can be thermal or steel rule die cut into pre-spaced letters or graphics. Your parts will have all excess scrap "weeded". The pre-spaced image will be supplied on a carrier and pre-masked with application tape. If you are using your carrier to locate your graphics during application, please indicate the size of carrier and placement of the image to carrier edge on your drawing.

SETS AND KITS

Do you have several labels that are used on the same piece of equipment? Are these labels being purchased individually, at different times throughout the year, from more than one vendor? Would you like to save money, improve inventory control, and reduce time spent on labels in purchasing and engineering? Of course, we all would. At DuraTech, we have been offering a service for years that can do just that. Whenever possible, order all your labels or overlays as part of a set or, if two or more materials are needed, as part of a kit.

By combining like parts (same material and adhesive) together and running through production on a common sheet, we can reduce the amount of labor (fewer setups in each department), prepress (artwork) and screen costs, and tooling costs. These savings are passed on to the customer as lower unit prices on a per label basis.

Imagine a food warmer, floor scrubber, or any piece of equipment. Each has several labels that need to be purchased. Currently, they may be on two or more similar, yet different materials. The materials do not need to be different. They were just designed at different times by different engineers, and purchased from different vendors by different buyers. Some of the labels are over-laminated and some are not. Some of the labels have black text and some have dark blue copy. Several have different shades of the "same" red. Why? No reason.

Does this sound familiar? It is not an uncommon occurrence. At DuraTech we will work with you to reduce cost. We can recommend materials, hopefully reducing the number of materials used to one or two. Consistent material specifications mean consistent performance. Many times, some labels are upgraded when they are combined with others. We can recommend other changes as well. Do you really need three different colors? If so, fine. If not, you can save money by reducing the number of colors. Also, a set gives you the opportunity to get those three different shades of red you were getting down to a consistent shade of a single red.

Besides saving money, there are other advantages. In many cases, an improved inventory control can be achieved by replacing ten or fifteen individual part numbers with one new part number given to the set. Production personnel have to find and pull product less as most sets or kits are provided on sheets (carriers) of multiple parts. These carriers provide an excellent way to ensure that all labels are available and accounted for at the time the product is assembled.

Please contact your customer service specialist and ask to speak with an engineer if you have any questions. We have sales engineers available to meet with you at your facility to look into the possibility of producing your labels or overlays as a set or a kit.