CHEMCAST®

The all purpose cell-cast acrylic sheet

Technical Manual

FINISHES AND PRINTING

UNIGEL

CHEMCAST®
The all purpose cell-cast acrylic sheet

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Screen printing

Graphic support

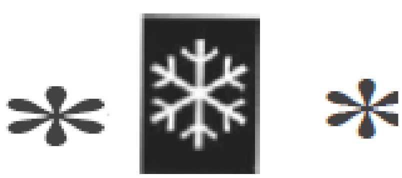
Screen printing as a means for graphic reproduction is supported by the procedures applied in graphic arts. These procedures are based on the key element which is the mechanical original, drawing or photographs.

The original mechanical is the means for preparing the cliché or stencil for graphic arts. This is a drawing that is supported by a white paper, preferably opaline, and the typography, drawings or patterns that can be hand made with India ink (deep black) and stylographs, halftones can also be used, either with pencil, watercolor, gouche, oil, pastel. Today with the help of personal computers and special packages for graphic design, excellent quality original mechanics can be obtained in no time.

It is recommended in some cases that the original mechanic is prepared 20% larger than the final size, with the aim of minimizing errors inherent to the preparation itself.

To obtain the cliché or stencil or screen printing, it is necessary to emulsify the mesh and perform the transport or the reproduction of the motif in mesh form permanently.

This requires that the original mechanical be passed to a photographic positive, which is the same drawing but instead of paper the support is an acetate. This process is performed in a photolith, where from the original mechanic a photographic negative is obtained and from this a photographic positive is obtained, with the advantage that the size required can be reduced or enlarged.



Photographs can be reproduced in high contrast or halftones when a monochrome will be performed.

Currently it is possible to print in full color, for this effect it is necessary to make a selection of color, this is to separate the four basic colors, which are: yellow, magenta, cyan and black, also called CMYK.

Equipment and materials

Work area and facilities

Screen printing is an integral part of most of the products manufactured in acrylic. This implies that this process is located as far away from the operations normally used in the manufacturing process of acrylic pieces, where the cutting, routing, grinding and polishing always generate shavings, burrs, dust or particles that in serigraph printing are simply inadmissible. For this reason, it is necessary that the serigraph printing requires a working area away from other operations and must also be a large well-lit area with good ventilation and dust free.

It is also necessary to have a small dark room for the exposure or transport and developing of the screen with electrical and hydraulic installations.

Equipment, supplies and accessories.

Below a list of equipment, materials and basic accessories for serigraph printing is mentioned. Some of these, such as mesh, inks, emulsions, etc., will need to be purchased from a supplier of materials and equipment for screen printing; other materials can be purchased in engineering and drawing material stores and even in hardware stores.

Equipment

Double hinges, hinges with sliding presses, flat printing table with suction and hinge, transport table with quartz lighting or photolamps, developing tub, drying rack.

Materials

Frames of various sizes, strickles of various sizes, photographic emulsion, sensitizer, screen cleaners, water and thinner based blockers, solvents, inks of various colors, cropping films, stubble, masking tape and cellophane tape, double-sided masking tape.

Accessories

Emulsifiers, graduated test tubes, beakers, tension clamps, stapler, cutters, graduated ruler, spatulas, PantoneMR* color guide, thread counter.

* Pantone is a trademark of PANTONE INC.

Each ink has certain properties and characteristics for the printing to be performed. As a rule screen printing inks are more opaque, bright and durable than other inks used in graphic arts.

Inks

The ink consists of pigment which is the part that gives color to the ink, the vehicle, formed by a varnish or resin dissolved in solvent, additives which is another group consisting of waxes, drying loads, etc., and solvent that can give the desired consistency or viscosity.

A good ink should not affect the mesh and strickle, or seep through the mesh, or obstruct it; it should lead to a detailed and uniform printing, drying in a reasonable time, have good adhesion to the substrate, it should be easy to thin and be eliminated through a proper solvent. Inks are classified depending on the type of application (material) requiring printing. Inks may be matt or shiny having different bases and are characterized by certain effects. Depending on the type of ink and its composition, it will have different ways of drying which are:

Evaporation

When the solvent evaporates, the ink dries on the substrate.

Absorption

When the substrate is a porous material that allows ink to pass inside and therefore dry.

Polymerization

It is the chemical process in which the monomers bind to form longer chains called polymers. This type of drying can be done for four reasons:

Oxidation

Enamel type inks require oxygen from the air to dry.

Catalysis

Some inks such as epoxies are presented in two components that when mixed in the recommended proportions, cause a reaction that promotes solidification.

Heat

There are special inks for textile applications that dry in air but require heat to complete their curing.

UV light

They are special inks that do not dry without receiving ultraviolet light.

Mesh

The mesh is the most important element in the screen printing process, so it becomes very interesting to know its function, characteristics, manufacturing, etc. Today, any vendor is able to provide the most appropriate mesh for all types of printing. The mesh functions as a support of the motif or pattern to be reproduced and regulates the passage of the ink.

Characteristics of the mesh

A mesh must have the following characteristics:

Good quality, good abrasion resistance, good resistance to films and emulsions and chemical resistance.

Meshes can be classified by:

a) Their manufacture.

Meshes are made of a single strand also called monophilic, or with two or more strands twisted together, or multiphilic.

b) The material used.

In the manufacture of meshes different materials can be used divided into:

Natural: silk, cotton, organza.

Synthetic: nylon, polyester.

Metal: bronze, stainless steel.

c) By their color.

The traditional colors are white, orange and red.

In general we can conclude that it is much better to select a mesh that is monophilic, because it has greater resistance to abrasion than a multiphilic. Synthetic type meshes are better because they are more durable than natural meshes and less expensive than metal meshes. In fact, natural meshes are used to print on lower quality and/or reduced production textiles. Synthetic meshes are the most used due to their versatility; those of nylon, for its flexibility, are used for prints on bodies such as cylinders, cones, spheres, etc., and those of polyester being a more rigid material are used for a better and greater registration of several colors and printing of flat objects.

Another very important point in selecting a mesh is the threads per cm2, below the recommendation is made of the mesh depending on the type of printing to be performed.

The color of a mesh is also important, white can be used on nylon or polyester up to 77 threads per cm2 and preferably in textiles.

Meshes of 90 threads and upwards are recommended for printing fine details, while it is better to use a red or orange to avoid light reflections at the time of exposure or transport.

The reflection of light is a phenomenon that results in the deflection of light when meeting with the natural color threads of the fabric the time of exposure that causes a bad stencil definition, this phenomenon is increased by increasing the number of threads per cm2.

In the case of orange or red mesh, these absorb all colors and reflect only orange or red, that has no influence on the exposure or transport process and hardening of the films and emulsions.

Mesh is recommended for printing on acrylic:

On regular or flat surfaces, it is best to use an orange or red **polyester** monofilament mesh of 90 to 120 threads per cm2.

On uneven or curved surfaces, for example with thermoformed pieces, it is best to use an orange or red **nylon** monofilament mesh of 90 to120 threads per cm2. Table No. 1 contains recommendations for the selection of a mesh.

Table No. 1 Recommendations to select a mesh.

APPLICATION	POLYESTER	NYLON
Thick textiles, sports bags, simple printing with stencils for drawing or cutting without great requirements or fine contour.	34 to 49 T	34 to 49 T
Rough or absorbent surfaces, printing on thick grain wood, simple prints with direct and cutting stencils.	49 to 77 T	49 to 77 T
Posters, large letters, opaque inks, fluorescent.	77 to 100 T	100 120 T
Screens up to 20 points per cm., fine letters and contours, scales, fine line printing with great registration requirements.	100 to 120 T	100 to 120 T
Very fine prints of the highest quality with direct-direct, indirect-direct stencils for reduced ink tank, with UV ink and screens of more than 20 points.	120 to 165 T	120 to 165 T
Printing on plastic bottles, advertising items, printing on lighters, pens, etc.	90 to 120 T	
Screens, reduced ink tank for fast printing machines.	120 to 140 T	

Frame

The purpose of the frame or rack is to hold and keep rigid the mesh to be used as stencil support, when the frame has this mesh mounted it is then formed with the screen name. The racks or frames are made of wood, aluminum or PTR (steel sheet tubular profile).

Materials Wood

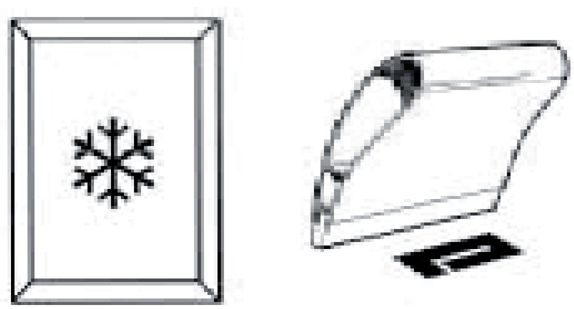
The wood must be kiln dried, with average hardness to be easily stapled, it should preferably be edged and brushed, frame joints should be well assembled and after construction varnishing it would be suitable.

Poor quality pine frames or racks are commercially available except for those imported, it is preferably better to build them oneself, with top quality pine or better with tropical wood, as by being harder and more resinous they better support buckling and moisture.

Most of the time frames are rectangular and the most common measurements can be found in Table No.2.

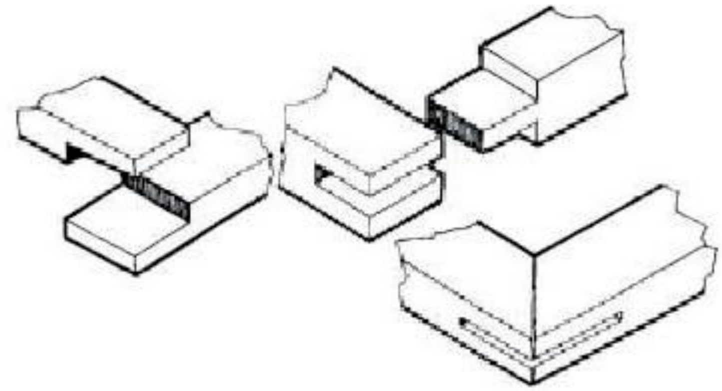
1/2" x 1/2" (CM)	3/4" x 1 " (CM)	3/4" x 1 " (CM)
20 X 30	40 X 50	49 X 59
30 X 40	48 X 58	69 X 79
40 X 50	40 X 70	79 X 99
	55 X 75	84 X 100

For the construction of the rack three things must be taken into account: the width of the strickle that comes in sizes of 5, 10, 15, 20, 25, 30 up to 80 cm. The width of the drawing or motif that should be of 1 to 2 cm. smaller than the width of the strickle and 10 to 15 cm. on the longest side in the shortest internal dimension (A) side and 15 to 25 cm. in the internal dimension of the longest distance (B) from the screen or frame as shown in the following illustration.



It is recommended having three different sizes of racks, small, medium and large. The dimensions of each will depend on the type of market sector that is being worked, for example illuminated advertisements or promotional items.

The joints of the corners of the rack will be the traditional for wood assemblies, as shown in the following illustration.



The measurements of the wooden slats for the racks are listed in Table No. 3.

FRAME DIMENSIONS	DIMENSIONS OF THE WOODEN LATH
Up to 30 X 40 cm. Up to 60 X 80 cm. From 75 X 100 onwards	3 x 2 cm. or 3 x 3 cm 4 x 2.5 cm. or 4.5 x 2.5 cm 5 x 3 cm. or 5 x 5 cm

Aluminum or PTR
The rack or frame made of tubular aluminum or black sheet has the advantage of being lighter than a wooden frame and will always remain perfectly straight or flat with respect to the printing surface.

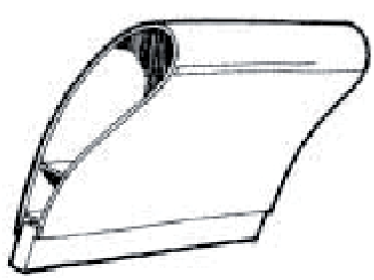
We recommend using a tubular profile 1 x 1" or 1 1/2" x 1 1/2" cal. 18 or 20, welded. It is much easier to weld black sheet but it rusts more easily. In fact it can be galvanized to prevent corrosion by rust. Aluminum is more difficult to weld but is fully resistant to rust and lighter than a black sheet profile. The tubular profile measurements may be as shown in Table No.4.

1x1" (cm.)	1 1/2" X 1 1/2" (cm.)
20x30	40x50
30x40	48x58
40x50	55x65
48x58	60x70
	60x80
	70 90

Strickle

The strickle is the most important tool in screen printing, the most essential and generally the one that receives less attention. This tool conveys the ink through the mesh and consists of a handle or grip which holds an elastomer sheet of certain flexibility. The handle can be wooden or also an extruded aluminum profile that adjusts to the hand with good ergonomics.

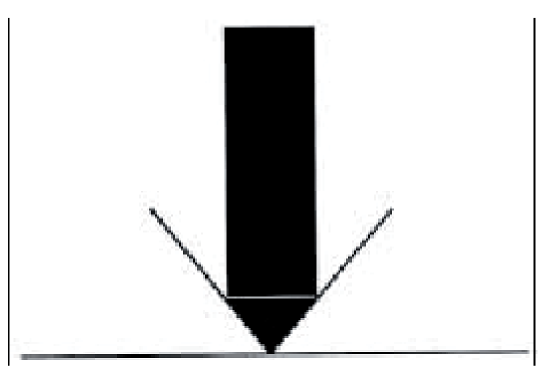
Currently the sheet is made of rigid urethane, it has good resistance to friction, wear and chemicals such as inks and solvents. Strickles come in standard sizes from 5 cm. up to 80 cm., in multiples of 5 cm., if a longer strickle is required it will be necessary to request it specifically.



The strickle works best if the blade is kept sharp, that is, if the two edges of the sheet remain square. With use, the strickle tends to round out at the corners due to friction with the mesh and due to heating, it also tends to soften due to subjection to pressure in different directions. In fact it is possible to square it again if there wet sandpaper on a very smooth surface (acrylic or glass) and sanding with back and forth movements with the strickle diagonally in the direction of movement as illustrated in the drawing.

It is important to clean the strickle with solvent as soon as you printing is finished, as well as being careful so that the blade does not have nicks or bumps on the edge, since these produce a buildup of ink that could affect the final printing.

Finally, in most cases the sheet is used with square edges, this edge is rarely modified except when they are round pieces, in this case a cutting edge is used at an angle between 30 and 60° as shown in the illustration.



Screen

It is the name by which a frame of any material with a stretched mesh is called that will serve as support for the motif or pattern to be printed. It is of vital importance to have screens with adequate tension, as a screen with low tension will result in runny printing and ink buildup, this means that the drawing will be deformed when applying pressure with the strickle and printing will be deformed. Too much tension will cause the mesh to be susceptible to tearing and partial or total loss of the screen. The following explains how a mesh can be tensioned by manual means.

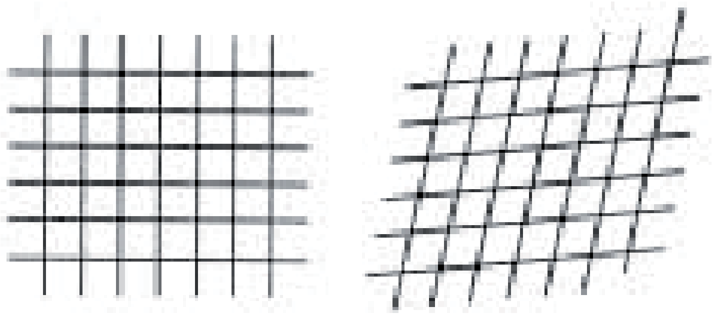
Manual tensioning technique

Preparation of the frame

Aluminum frames do not require special preparation, black sheet frames should be painted with epoxy paint or galvanized. Wooden frames are should be sanded entirely and then varnished or painted with oil based paint, this is for the purpose of avoiding the absorption of water when subjected to the developing or recovery process done with water, which causes the frame to become twisted or deformed.

Manual tensioning technique

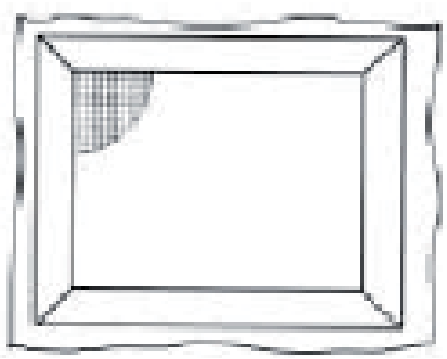
For tensioning meshes it is best to send the meshes to be tensioned by ink suppliers, when you still do not have the necessary experience, these companies have appropriate equipment to tension the mesh without deformation and with the approximate tension of 14 to 16 Newtons, which is the tension at which a mesh should be at. A tension where the threads are deformed or are not perpendicular to each other causes defects in the final print.



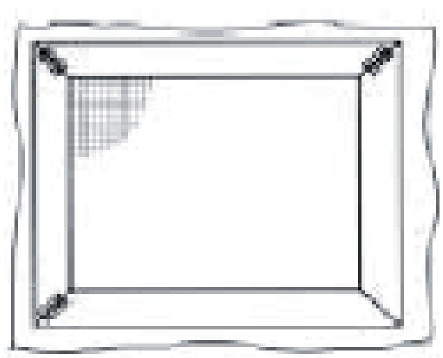
Uneven tension causes the threads of the mesh to deform causing uneven printing.

It is very important that proper tension of the mesh is achieved in the frame, poor tensioning will present irregular printing. To tense a mesh on a wooden frame it is proceeded as follows:

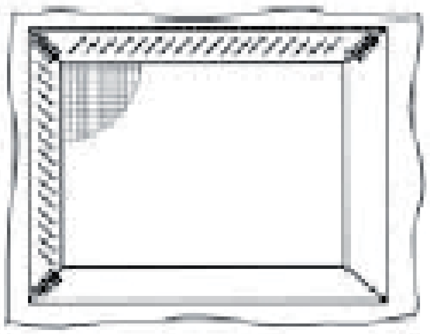
Cut the mesh about 5 cm. per side larger than the frame. The mesh is placed over the frame making sure that the fabric is parallel to the frame.



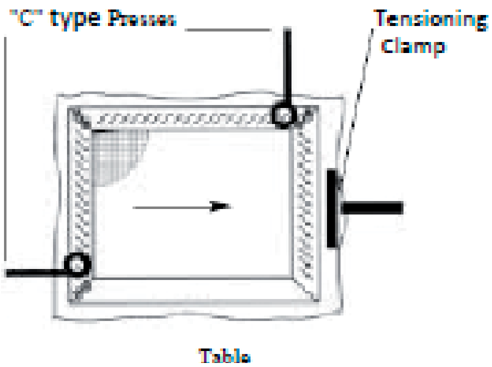
Two corners of the frame are stapled taking care that the staples are at 45° and with a spacing of 5 to 10 mm. between each staple.



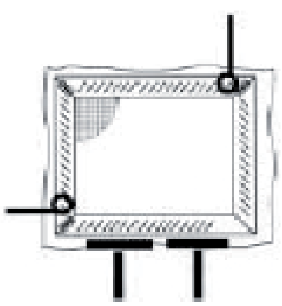
Staples are placed at 45° every 10 to 15 mm. on either side (this is done with the object of the staple not tear the mesh).



The frame is pressed with two "C" presses on the edge of a table and the shorter is tensed first with a tensioning clamp and stapled as previously mentioned (if nylon is being tensed it can be wet slightly, this will help it to be more tensed).



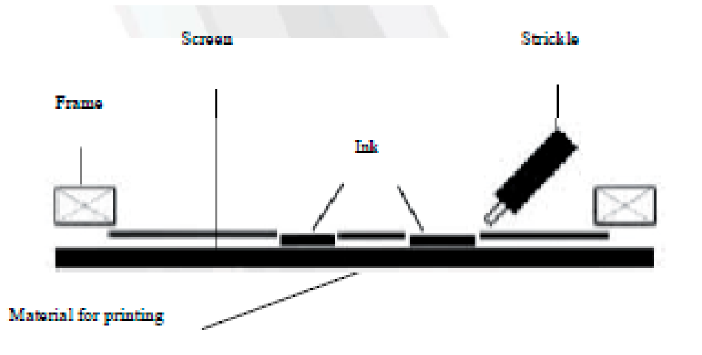
The last side is tensed, stapled and the overlap cut with a cutter and lastly a wood varnish or lacquer is applied on all staples with a brush.



Cliché or stencil

It is essential to establish the differences between screen printing and those which can be obtained by other means such as printing, offset, etc.

Screen printing is done through the cliché or stencil and in the other methods directly from the stencil. In other words, screen printing is achieved by passing ink through emulsion-free zones, that is through the stencil, in printing and offset the printing is accomplished by the ink being impregnated in the cliché or stencil.



In screen printing a cliché or stencil can be obtained through the following methods:

• Direct method

• Direct-Indirect method

• Indirect method

Printing

Process

Direct method

The direct method is obtained from a photosensitive emulsion may be textile (for printing on fabric) or non-textile (for printing on paper, wood, plastic, etc.). It is applied directly to the mesh and hardened by light.

Direct-Indirect method

In this method the application of a photosensitive emulsion is combined with a polyester based film that adheres to the emulsion, also known as chromaline.

Indirect method

In this method the cliché is achieved with trimming films, there are two types:

a) Vinyl-based that sticks with thinner.

b) Polyester-based that sticks with water. For this method it is necessary to trim the motif before adhering it to the screen, the motif needs to be trimmed in negative. This method is ideal when low complexity or large size lumps, backslashes or drawings are required, runs of up to 300 to 500 pcs can be made.

This chapter will explain the screen printing process or technique, comprising from cleaning and recovery of the screen, to the printing itself. Like all manual labor it is desirable that each stage of the process is done with the utmost care to avoid deviations that can sometimes be difficult to resolve.

Cleaning and recovery of the screen

Once the mesh has been tensed and stapled to the frame, it will be necessary to clean residues of dust, grease, etc. This cleaning or recovery operation will need to be performed every time cliché needs to be changed, regardless of if the frame is new or used. In general terms, the steps to follow are:

When the screen is new it is recommended to use some abrasive paste, which acts as a degreaser, removing ink and residue from the stencil or cliché. The screen must be left at rest for the time specified by the supplier and washed with plenty of water. Subsequently specially formulated products can be used for total cleaning. Some people prefer to use common solvents such as thinner, bleach, gasoline, etc., but they have the disadvantage of damaging the mesh.

When the screen has already been used, it is best to first use an ink remover, let stand, rinse with plenty of water; and then use an abrasive paste that acts as remover of ink and residues from the stencil. At the end it is necessary to use concentrated demulsifiers washing with sufficient water at pressure if possible. (There are very practical portable type devices on the market for pressure cleaning).

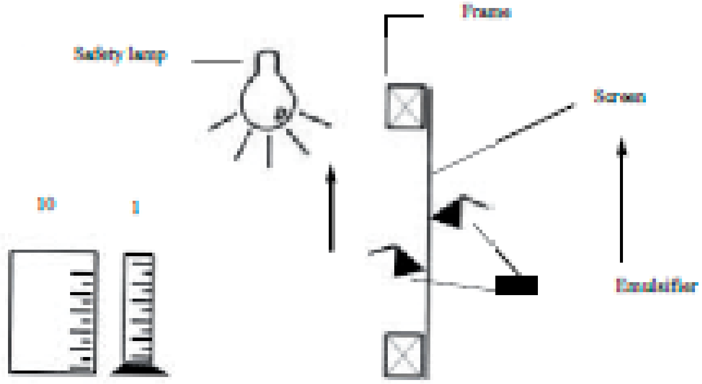
Screen emulsifying

All suppliers of screen printing inks and accessories have two types of

emulsions, textile and general use. The general use emulsion is used for printing on acrylic, some suppliers also have two types of emulsions depending on the type of sensitizer used, being dichromate or diazo compound. The latter is ideal for printing without much chromaline detail. The disadvantage of this emulsion is the lifetime in the container, which is approximately two months depending on environmental conditions and especially not being exposed to light.

The most commonly used is the emulsion with dichromate, stocked by most suppliers with 10 parts of emulsion for 1 of sensitizer, it must be remembered that most emulsifiers have a shelf life of one day so it is recommended to prepare only the amount needed. To prepare the mixture it is necessary to do so in a dark room with safety lighting, as the emulsion is sensitive to light and can degrade.

To emulsify the screen it is necessary to pour the sensitized emulsion over an emulsions applicator, applying two or three coats followed by both sides, the screen must be placed upright and with the same applicator excess emulsion is removed, taking care that a not very thick layer of emulsion remains. This operation is performed in an upright position until it dries, it can even be helped to dry with electric fans.



Exposure and transport

Exposure or transport refers to obtaining of the cliché or stencil on the screen, ready for printing. The way to achieve this is emulsifying the screen as already explained, then placing the photographic positive over the screen to harden the emulsion through light in areas where there are no traces; in this way the dark areas of the emulsion positive will not harden and allow passage of the ink. An overexposure is usually better than an underexposure. However, when optimal definition and stencil life is required it is indispensable to achieve the correct exposure, which is a function of time.

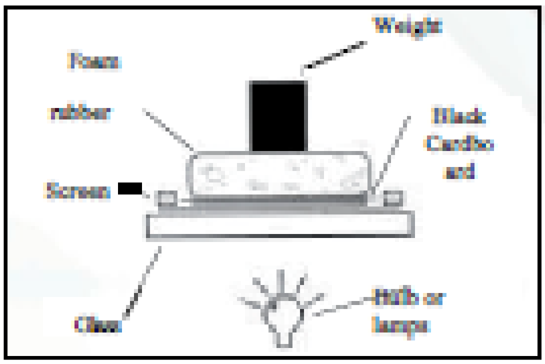
Exposure

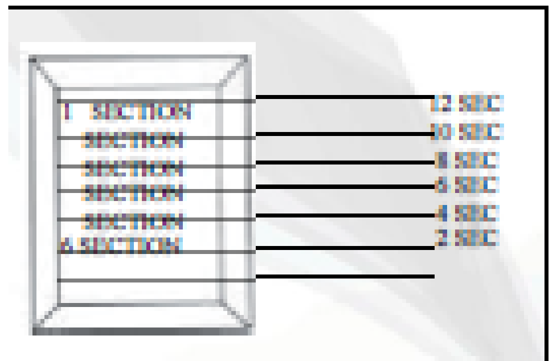
Adequate exposure is achieved by:

Placing the photographic positive in direct contact with the screen emulsified on the outside, fastening the positive with clear tape.

Placing the screen on the vacuum table or transport table, checking that there is good contact. The best way to make contact is with a vacuum table, because as its name implies, it will cause the frame or screen to be in close contact with the table support that is glass. If there is no vacuum table, it may be done on a transport table whose surface may be a glass of 8 to 10 mm. thickness. The screen, a black cardboard, a piece of foam rubber and a heavy object such as a sandbag or something similar will be placed.

The exposure time depends on the distance between the lamp and the stencil, the type and number of lamps, the thickness of the emulsion layer, the color and thickness of the fabric and the transparency of the photographic positive, making it difficult to establish an exposure time. The best practice is to perform an exposure test which involves exposing the entire screen by sections, so that if a section is exposed for 2 seconds and covered with a black cardboard and the rest is moved by sections at the same time it is exposed, at the end of the exposure the time for the first section will be the sum of all sections and the last section will be only 2 seconds.





Developing

The developing is carried out in a vat and sprayed with cold or warm water allowing to rest for some minutes, then the water jet can be gradually increased until the image areas are uncovered and left clean and defined; the screen must be placed in a vertical position until dry.

Printing

The printing process includes several steps: blocking, recording, squaring and printing itself. In this section we will discuss each of them.

Blocking

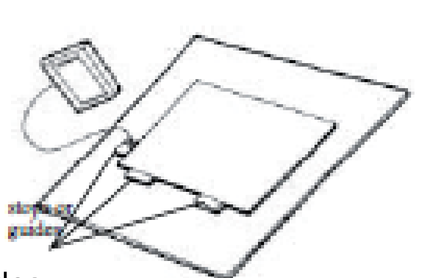
Often the dust trapped on the vacuum or transport table causes dots appear in the stencil where the ink can pass. If so, it will be necessary to use a water or lacquer blocker, depending on the type of ink used. For textiles inks are water based so a lacquer blocker should be used, otherwise, if solvent-based inks are used it will be necessary to use water-based blockers. Also, it can also be retouched with the same sensitized emulsion and left to dry.

Recording

Once blocked, the screen will be placed on the printing table with hinges and the frame will be adjusted to these. There are many ways to make the records, perhaps the most used is false recording, which involves placing an acetate between the screen and the printing table attached with cellophane tape on one side. Subsequently, with already prepared ink it is printed onto acetate waiting to dry; once this is done the piece to be printed is placed between the acetate and the table adjusting measurements with a ruler or scalimeter.

Squares

When printing on acrylic small rectangles of 3 x 5 cm. of acrylic of the same thickness can be used as stops or guides. These can be adhered with double-sided masking to the table surface. These squares or stops have the function of giving the record previously done and with this place the pieces to be printed with the speed required in the printing step.



Stops or guides

Printing

It is the last stage of screen printing. Everything done before is in order to be the medium for printing, if all the above was well done is very likely that the problems that may arise are minimal.

At this stage it is very important to select the type of ink depending on the substrate, as well as the consistency, a very watered ink will take time to dry, it can be extended beyond the design (if the material is porous), the color tone can be changed, etc. By contrast, a thick ink can dry too fast or block in areas of very small or narrow design, the ink must be adapted depending on the motif or design of the material to be printed and especially on ambient temperature, there are even retardants that are convenient to use when the ink is drying too quickly.

It can be concluded that one of the major problems is the consistency of the ink, if it is appropriate to the mesh, design and ambient temperature most of the process will be controlled.

Another variable in the printing process is the distance between the mesh and the material; generally speaking, a distance of 5 mm. is adequate, but would need to adapt to particular needs. Also, if the frame is wooden it will tend to sag, so it will be necessary to adjust this variation.

The strickle, which is the tool that allows to print, must be handled considering that it is better if taken with both hands and with a 45° angle with respect to horizontal.

Most screen printers strickle towards them, but it can also be done in reverse. Special care should be taken in force when strickling, as with a lot of ink pressure it could run and with low pressure areas will not printed. The movement should be forceful and decisive, the speed will depend on the person, but in most cases will be quick. The printing process is quite fast and requires two people to carry an appropriate pace. Depending on the size of the printing and the number of inks thousands of runs can be made in a day.

There are inks for acrylic that dry in between 5 and 10 minutes, which is very convenient if the run is of some hundreds or thousands and especially if the print is with two or more inks, but if the design is very detailed and ambient temperature a bit high, it is convenient to incorporate a retardant to the ink so that it does not clog too often. Another drawback that can occur is the space required for drying the pieces, it is advisable in this case to have special drying racks to optimize space.

Special Cases

The screen printing process requires continuous practice that provides experience and depth of knowledge. In the case of acrylic no deep knowledge is required for its screen printing, as generally 1 or 2 inks are printed and exceptionally four or more. It is now possible to print in color selection (or CMYK), but this option is limited by cost and the applications that could be done are overcome by other methods of further technological development and lower cost, except for the printing of advertising material on a plastic or acrylic.

In this chapter we will deal with the selection of color, degraded colors and the printing of thermoformed pieces.

Color selection

First, it is necessary to have an original which in this case is a color photograph or a drawing where by the number of colors represents an advantage using this method. Color separation will be necessary afterwards, obtaining four photographic positives. Today there are companies specialized in this type of work employing scanners, computers and special software for the production of color separation with high quality and speed.

These positives will need to be emulsified in four "recording" meshes and the most important thing is to take care that the four inks "fall" exactly in these records, failure to do so will cause a color separation without achieving the desired effect. A so-called "moiré" effect can also be produced referring to the waters, drawings or weaves with a certain geometric character (circles) that are repeated more or less regularly and are produced by overlapping grids at certain angles.

In screen printing it will be more complicated as the fabric mesh is involved that is also a weave. To prevent the formation of moiré, it will be necessary to have more weaves in the chamber so that the four have points at different angles.

Degraded colors

A degraded color is very easy to make, it consists in strickling instead of one color, two or more colors at a time; this requires pouring the inks to be printed, making a mixture with the strickle and proceed to printing. The only downside is that all prints will be different.

Thermoformed pieces

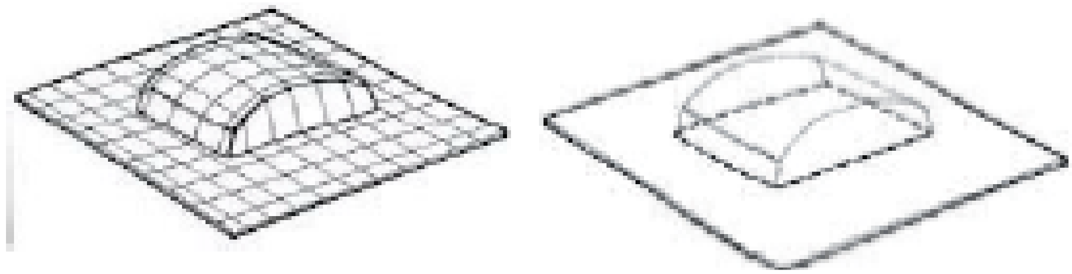
Of the three special cases, the most important is the screen printing of thermoformed pieces. A general rule cannot be applied on how a piece is to be printed, because some can be printed after thermoforming and with others it will be necessary to print them before.

An example of a piece printed after thermoforming is the crest of a public phone booth, in which after thermoforming the word phone is printed on the inner face with a curved frame.

There are pieces that will need to be printed after thermoforming as is the case of lighted ads or others where the bas-relief is the printing area. There are two methods to do this type of printing:

On the acrylic sheet cut to fit the mold, a grid is mapped every 5 or 10 cm, depending on the size of the piece; the sheet is heated in the oven and is thermoformed, then the distortion of each picture is observed and a deformed template is obtained for the screen.

Another method is thermoforming the piece, marking the outline of the drawing with a permanent marker and then returning it to its original state by heating it again in the oven until it adopts its original form, the cliché will be done taking the distorted picture.



Troubleshooting guide in producing stencils

PROBLEM	PROBABLE CAUSE	SUGGESTED
Poorly defined (sharpness of edges) or irregular contours.	Poor contact during exposure. Underexposure. Light diffusion, insufficient developing, poor coating of meshes, fabric too thick.	Check the vacuum table, test of exposures with different times, use orange or red fabric. Develop well on the sides, improve the application technique. Use finer fabric.
Soft stencil.	Defective mixture of sensitizer. Underexposure. Emulsion expired, positive film yellowish, excessive moisture.	Mixing in specified amounts, gradual exposure testing. Check storage date. Use new positives. Dehumidify the workshop.
"Veils" on the parts that are to be printed.	Insufficient intensity of black of the positives. Poor contact during exposure. Light diffusion. Pre-exposure of emulsified screen, over or underexposure. Insufficient developing.	Use new positives. Check the vacuum table using orange or red fabric. Work with yellow light. Store screens in the dark. Test of exposures with different times. Check the developing process.
"Pinholes" appear after exposure and developing.	Dust and impurities deposited in the emulsion during drying. Dust deposited on the positive or on the	Dry rhe screen in a place without dust. Clean the tank. Clean the glass from impurities with suitable products, glass cleaner
The emulsion falls or peels in parts during developing.	Non-uniform emulsion application. Defective mixture of sensitizer. Underexposure. Insufficient penetration of the fabric. Temperature of developing water too high. Emulsion expired.	Improve fabric tension and the application technique. Mix in specified amounts. Test gradual exposures. Degrease all fabrics, try to degrease all new polyester fabrics. Develop at maximum 35° C. Check the date of storage. Using air drying, prolong the exposure time.

PROBLEM	PROBABLE CAUSE	SUGGESTED
"Pinholes" appear before exposure.	Insufficient degreasing of fabric. Dust and impurities in the workshop. Moist mesh. Dust and impurities deposited on the emulsion applicator, strickle or emulsion pot. Emulsion application too fast. Air bubbles when mixing.	Degrease thoroughly. Regularly clean the workshop. Dry the mesh well. Clean the applicator or strickle. Do no hurry after each pass. Turn the screen 180°. Let the air out of the emulsion for at least one hour.
"Pinholes" during printing.	Insufficient application of emulsion. Underexposure of aggressive solvents in the ink or incompatible solvents in the cleaning product.	Improve the application technique. Test of exposures with different times. Use emulsions resistant to solvents. Do not store solvents in large containers to prevent condensation. Change the cleaning technique. If the emulsifying and exposure are correct, use an abrasion resistant emulsion.
Fine details remain closed after developing.	The emulsioned screen has been stored for too long. Preexposure of the emulsified screen. Drying temperature too high. Overexposure. Defective positives. Light diffusion. Light source too weak. Insufficient developing. Light source too close.	Use a fresh emulsion for the details to open well. Work with yellow light. Keep the emulsified screens in the dark. Do not dry at more than 35° C. Gradual exposures test. Check the vacuum table. Check the black intensity of the positives used. Use a finer fabric. Use a faster exposure emulsion. Improve the light source. Develop with plenty of water on both sides.

Plating

Introduction

Among the most important plating procedures for plastics is plating of metals in high vacuum. Vaporized plastics have been imposed in many applications, particularly not only because they offer technological advantages, but also because they can be coated with thin layers of metals or oxides in extraordinarily cost-effective ways.

The first plated plastic articles in series were produced in around 1938 in the United States, based on polystyrene and cellulose acetate butyrate. It was accessories for refrigerators and cars, the field subsequently opened in the areas of appliances, in the electrical and toy industry as well as jewelry, cosmetics and souvenirs.

The excellent properties of the vaporized layers not only opened new possibilities for application to plastics, but also stimulated the development and construction of facilities for high-vacuum plating.

Vaporizing consists in the separation of precipitates in a thin layer on a base, from the vapor phase. The physical name for this phenomenon is condensation. All materials (pure elements, e.g. metals, as well as compounds, particularly oxides) may be solid, liquid or gaseous. Their state at a given time depends on temperature and pressure. While the passing of a solid to liquid is hardly influenced by air pressure, the transition to the gaseous state is pressure dependent, it may be inferred that vaporization is prevented by the air present. Therefore, large amounts of steam can be produced with less energy in a chamber lacking air, not mixed with residual gases.

The material to be vaporized is heated in a suitable crucible until it becomes steam in sufficient amount, that is, until the vapor pressure necessary or essential vaporization speed are reached. The vaporized atoms leave the surface with a flight speed of several hundred meters per second. The motion occurs in a straight line until they hit an obstacle (container wall, substrate or residual gases). The number of residual gas molecules present can be calculated based on the pressure in the vacuum boiler.

The high vacuum is therefore essential for a steam straight line expansion, since collisions with residual gases lead to unwanted reactions that limit or prevent the metallic sheen. The residual gas pressure should therefore be, in vaporized plastics with aluminum, about 10-4Torr. *

* 1 Torr = 1 mm of Hg = 1.33 mbar = 133.32 Pa

Surface preparation

A fundamental requirement that applies to all plastic parts and certainly for acrylic to be plated is perfect cleanliness. The remnants of oil and mold release agents produce stains in layers, insufficient adhesion or distribution difficulties in basecoats that are necessary, so minimal handling of the piece along with a thorough cleansing is essential.

For thermoformed parts it is advisable not to use silicone-based mold release agents, as they can only be removed by intensive cleaning and appear as dark areas after the plating.

Also surface impurities should be avoided, such as hand sweat. A good safety measure is the packing of the pieces in plastic bags until the time of plating and lacquering. In addition, staff handling such parts must necessarily have cloth gloves. Metals suitable for plating include aluminum, silver, gold, copper and chromium.

Among oxides, silicon monoxide should be primarily named. All substances for vaporizing must be as pure as possible. Impurities by foreign bodies can lead to unexpected results, such as changes in layer color and lower adhesion. Alloys are not suitable for vaporizing as the various components almost always have different boiling points and do not vaporize concurrently.

Materials and **vaporizing sources**

For heating of substances to be vaporized, vaporizers heated by the direct passing of current are generally used. Regarding material and form they must be appropriate for the process and present a much higher melting point than the substances to be vaporized. They also cannot react with substances or only very slightly, as this would have negative effects on their duration.

Usually tungsten, tantalum or molybdenum vaporizers are used. They are supplied in the form of small bars, chapales, spirals, crucibles or navecillas. At present plastics with aluminum are generally vaporized, tungsten spiral is preferably used for this in production facilities, which is now the most cost-effective solution for vaporizing aluminum. The vaporizer spiral formed by several wires of 0.3 to 0.8 mm. in diameter twisted and processed to form the spiral, is able to cover a relatively large amount of liquid aluminum.

For the loading hooked aluminum wires are hung from the spiral or strips or wires are placed inside said spiral. Upon heating, these elements melt and wet the various sections of the spiral. These vaporizers can be used for up to 40 loads always using aluminum, it is best not to heat the vaporizers too much to prevent leakage of liquid aluminum. However, aluminum that eventually does leak is collected in tanks arranged for this.

Plating process

After appropriate treatment of the surface the parts to be plated are introduced in a vacuum chamber by means of a feed grate. Next the chamber is closed relative to the atmosphere and a vacuum is created. To improve the adhesion an intensive discharge of about 10-1 Torr is sometimes produced before vaporizing.

With the voltage applied for this it ions and electrons are released from an electrode that reach the surface to be vaporized. The electrode is made of a material hard to pulverize, almost always aluminum. Discharge times are very diverse, ranging between 1 and 10 minutes depending on the type of plastic. The cleaning effect and improved adhesion achieved with the discharge is due to several causes:

The colliding particles tear of gas and water remnants, so that they can be removed with the pump.

The pieces are heated, wth the Ion collision surface atoms are torn from the pieces, so that these are slightly rough and the vaporized layers acquire better adherence, without losing shine.

The bombardment of electrons and ions forms germs for subsequent condensation of the layer.

Upon reaching the required vacuum, the material to be applied is heated until it vaporizes and condenses on the pieces. This completes the plating process, the chamber is aired and the plated pieces are removed. The chamber is ready for a new cycle.

The thin vaporized metallic layer sometimes requires protection, necessitating a subsequent appropriate lacquering, the lacquer has to protect the metallic layer from mechanical wear, corrosion and weathering influences, moreover, it should not harm the acrylic or the plated layer.

Post Lacquering

In pieces where the maximum reflection matters or they are not subject to any effort, the protective lacquer is often ignored. In this case often a thin layer of silicon monoxide is vaporized.

If a long life of the pieces is required, it is better to vaporize aluminum instead of silver. Even the best protective coating is not completely free of pores and neither is it so resistant in the long term as to protect the thin layer of silver and avoid its blackening or discoloration as a result of the weather.

Plated acrylic

Applications

Unlike other plated plastic, acrylic has the enormous advantage that by being a transparent material in nature, the field of application is quite wide. The replacement of glass-mirror for plated acrylic in areas such as nurseries, hospitals, dance halls, restaurants, discos, etc., provides not only beauty and functionality, but also greater safety by being more resistant. We must also consider the potential for use in thermoformed pieces as convex mirrors, thermoformed panels and special pieces.
Because the machinery is costly and does not justify its investment as part of the equipment, the most reasonable in the case of requiring acrylic plated pieces is to outsource to specialized suppliers.

Hot Stamping

Introduction

The hot-stamping technique is one of several finishes that can be given to the acrylic sheet. It has the enormous advantage of being a very reliable procedure as the two process variables are temperature and pressure, controlling these variables from the beginning is possible to obtain a very homogeneous quality throughout the production.

This finish provides printing runs that reach the order of 100,000 units with minimal cost in preparing the cliché which is usually steel or brass. The plated finish gives the finished piece a pleasant visual and touch sensation. In this chapter we will review what the technical details to achieve a good result are.

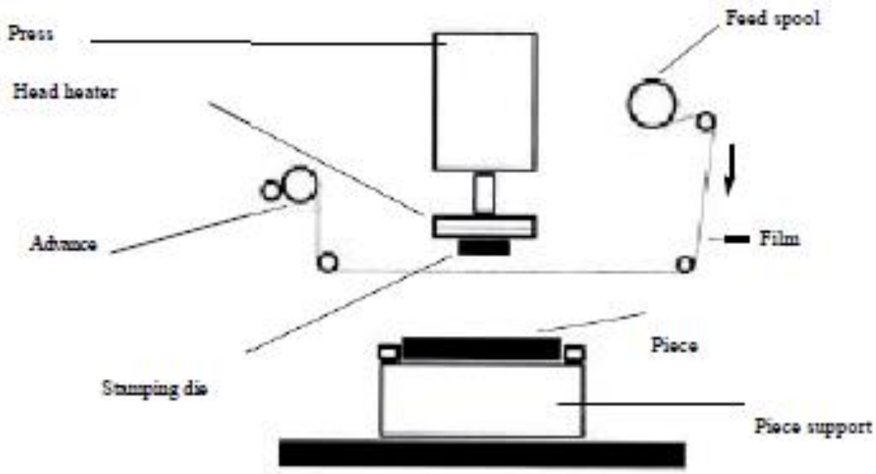
Hot stamping is understood to be the application of films on the surface of the acrylic through a heated die with a desired relief image, drawing or graphic element. With this procedure large surface areas or also lines or points can be obtained.

Hot Stamping (hot-stamping)

Hot stamping is done through the action of pressure and heat. The die may be of steel, brass or also silicone rubber. According to the stamping films to be applied, as well as the material of the plastic surface to be treated, the die is heated to temperatures between 100 and 200 °C; during operation the film is conducted from the feed spool between the die and the piece and the descending die presses strongly against the workpiece surface. The spindle heating makes the layer separate from the film stamping that serves as support. The heat simultaneously produces a melting of the surface in the case of thermoplastic polymers such as in acrylic, thereby improving the adhesion of the embossed film.

Metal dies are generally used for the stamping of thermoplastic and thermoset polymers, it is preferable to use a steel die, especially for big runs. Steel dies provide the best results and because of their hardness, are the most resistant to wear and also inappropriate treatment. Brass dies are preferably used when it comes to runs under 100,000 units.

When designing dies, it must be taken into account that the engraving has no vertical walls, but with an angle of 12°. It is also important that the ends are not acute, even in the case of dots and lines there must always be a flat surface.



In special cases, dies can be manufactured of silicone rubber, specifically provided that the surface is flat or when for any inaccuracies in the production of the pieces the differences have to be compensated.

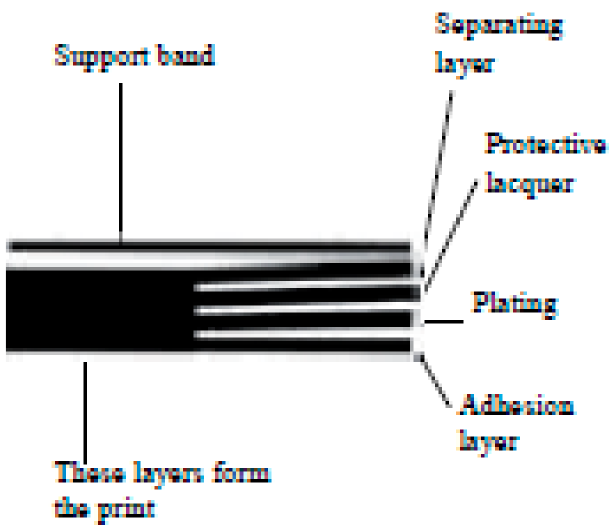
Silicone dies are cast in negative molds and then vulcanized over a metal plate. The dies typically have a Shore hardness of 80°. Only in case of prints with very sharp edges the Shore hardness is reduced to 60 - 70°.

The dies are screwed or fixed with special adhesive tape to the metal plate of the press. In the case of the silicon die, because it is a poor thermal conductor the loss of heat for the stamping that lies in the range of 50 to 80 °C must be taken into account. While metal dies use high pressures, silicone dies can only work at much lower pressures. Their duration varies between 50,000 and 120,000 pieces.

As each graphic and material provide different conditions, it is difficult to set guidelines for pressure, time and temperature: for reasons of production cost it should be attempted to minimize the time to obtain a high production. Moreover, a short time allows the acrylic surface not to heat excessively, avoiding its deformation particularly in thin sheets.

The temperature is determined by the combination of the film and the workpiece material. At elevated temperatures (over 150 °C), color changes in the film or excessive deformation of the workpiece surface can occur. If the temperature is low (less than 120 °C), it may happen that the film does not bind to the acrylic.

The formation of a print film is shown in the following illustration. It consists of a strip or ribbon support that does not pass on to the piece and the stamping layers whose composition will vary depending on the type of material to be printed such as paper, wood, leather, and plastics. The color characteristic of the film obtained in the metallic effects by combining pure vaporized aluminum and the colored protective lacquer. Nonmetallic films have colored lacquer instead of a metallic layer.



The various possibilities for printing on plastic surface are given by the stamping procedures that are classified as:

Positive stamping

The most common type is the positive stamping. An engraved die with mirror symmetry is used, which is pressed onto the workpiece.

Surface stamping

For surface stamping positive dies are also used, but they have a rounded shape to expel air entrapments originating in large surfaces. Thus, the die first contacts the center of the stamping.

Embossing

In embossing films are applied on elements protruding from the plane of the piece. For this silicone stamping plates without relief are used.

Negative stamping

Negative stamping is understood as the application of a stamping film in which images or punched labels have been obtained. When stamping, a negative image is obtained: the negative stamping can be combined with a positive stamping, then the negative image of the entire surface appears in the same tone as the base and an additional positive image in another tone.

Reverse stamping

It is used whenever transparent material such as acrylic is stamped. The die should not have mirror symmetry, from the technical point of view, this method is a normal stamping. A special effect can be achieved by further painting the entire free surface.

Films for hot stamping (hot-stamping)

There is a wide variety of films for hot stamping divided into three types of finishes: metallic, gloss and pigmented in white, blue, red, brown, green, black, silver, gold, etc. Below the cutting widths of films for stamping are listed.

Table No.5 Standard widths for hot stamping films.

WIDTH OF CUT (inches)	No. OF CUTS	WIDTH OF CUT (inches)	No. OF CUTS	WIDTH OF CUT (inches)	No. OF CUTS	WIDTH OF CUT (inches)	No. OF CUTS
1	24	17/8	12	27/8	8	37/8	6
11/16	22	2	12	3	8	4	6
11/8	21	21/8	11	31/8	7		
11/4	19	21/4	10	31/4	7		
13/8	17	23/8	10	33/8	7		
11/2	16	21/2	9	31/2	6		
15/8	14	25/8	9	35/8	6		
13/4	13	23/4	8	33/4	6		

Spray-painting

Introduction

Spray-painting is another of the many finishes that can be given to a sheet of acrylic, it is basically aimed at two types of application, the most important is the one that refers to the application of paint to base or provide a specific color as "base" of a generally thermoformed clear acrylic sheet as in the case of neon signs, where a homogeneous application in the layers of paint will be needed so darker or lighter areas of the color applied cannot be seen. The other application is to give it a specific color as a base, regardless of whether the piece is transparent or colored, this is rarely used, so we shall focus on the first case.

Spray- Painting

Spray-painting or painting with an air gun provides the acrylic sheet with a finish appropriate to the requirements for illuminated advertising, indoor and outdoor signs or special pieces. The process is relatively simple and comprises the following steps:

Surface preparation

A clean surface is absolutely necessary for a successful application of the paint. Grease, moisture, oil, fingerprints and other stains on the acrylic sheet must be removed using a sponge or soft cloth with liquid detergent without rubbing too hard, then it must be rinsed with clean water until the soap disappears completely. This is very important to prevent bad paint adhesion.

To remove adhesive tape or protective paper residues, isopropyl alcohol or naphtha is used. The accumulated electrostatic must be neutralized to prevent the irregularity of the paint layer. The simplest method is to clean the surface with a synthetic sponge dipped in naphtha, isopropyl alcohol or water, and squeeze as much as possible.

Maintaining a relative humidity of 165% in the paint shop, the problem of electrostatic will be greatly eliminated. The surface must be completely dry before starting to paint and it should be at room temperature if the piece was thermoformed.

Paints suitable for acrylic

For outdoor applications and when the paint is applied on the outside, this must be of excellent quality and resistant to the environment, we recommend using acrylic based paints (enamel or acrylic lacquer) that are resistant to solar radiation. Although not necessary, a protective layer can be applied to your graphic with matt or glossy lacquer. For ads in the open, a first layer of transparent acrylic resin will increase the duration of the finish.

It is preferable in all cases to paint the inside of the product, since the acrylic sheet provides a protective layer and an outer surface of excellent appearance. In this case alkyd based paints can be used, cellulose based paints should not be used as they attack the material (acetone, toluene). Some paints that contain organic solvents may crack the acrylic.

When the paint is applied to the acrylic sheet before being thermoformed, a paint which resists temperature must be used and with sufficient elasticity to conform to the shape of the finished piece.

Paints that resist adhesives after being applied exist on the market, the acrylic-based paints fulfill this function.

Before buying the paints, explain the type of material and the use for which it is intended to the supplier. There are a lot of solvents for each type of paints, so it is necessary to ensure that the product that is used is the most suitable.

The paint should be mixed uniformly to obtain a uniform distribution of the pigment, also a transparent base must be added to allow the passage of light. It is also important to use the proper type and amount of thinners as too thin may affect the durability of the paint and it will drain, a paint too thick can cause splashing and obstruct the air gun.

Spray application.

Applying paint by spraying is the most common and easiest method. The acrylic can be painted with one or more colors, using common techniques of masking or templates. Take care to avoid those with solvents such as acetone, toluene or thinner. When several colors are to be applied latex-based film masking is particularly useful. This film is applied by brush and allowed to dry. The paint area is removed by cutting just the top layer of the cutout film. There are several kinds of blades for cutting on the market but few can compete with a surgeon's scalpel. There are also rotating blade knives that are very useful if you know how to use them, as they best adjust to hand movement when a curve is made, care should be taken not to cut the acrylic surface. The excess parts corresponding to the areas that are to be painted are detached with the same blade. Some films leave residues that must be removed with naphtha or isopropyl alcohol before painting the exposed surface. They can also be masked in the traditional way of painters using masking tape

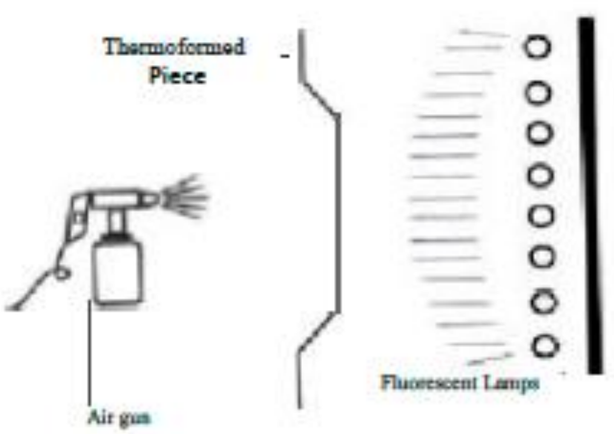
To achieve a better finish with the air gun, it is better to apply several light layers than one pass of thick paint, in addition to it drying faster. The paint should be shaken well before and during application to obtain a uniform distribution of the pigment.

In case the color matching of a group of objects to be painted to another is important, the viscosity of the paint must be measured with a Ford or Zhall cup for it to be constant. Ask your supplier to do the matching or provide the percentages. When using thinner, follow the manufacturer's instructions carefully, misuse or wrong amount used can cause serious defects in the surface. Also consult when mixing pigments, as by combining two stable colors an incorrect mixture can occur.

On pieces painted on the reverse, the process is repeated for each additional color, fully painting the exposed area every time. To paint frontal areas, the painted areas should be remasked or covered with siliconized paper before applying the next color.

Illuminated advertising

To paint some products such as illuminated advertising or signs in which lights are placed behind for show purposes, it is advisable to illuminate the rear part when applying the paint; it must be ensured that the light transmission goes through the colors used and give a uniform distribution on the surface.



Equipment for spray painting

First it is desirable that the place intended for air spray painting must have good ventilation. Depending on how often the equipment can be used from a 1 **HP** compressor to one of 5 **HP,** the compressor capacity is determined by the type and number of air guns to be used, a storage tank will be necessary. The gun may be low pressure of 40 lbs. or if a fine finish is required guns of 60 lbs may be used. The compressor air should be clean and dry so it should have the necessary filters. The diameter of the hose is determined by the given and allowable pressure. The interior of the gun should be cleaned every time the equipment is used or when the color is changed.

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