Fluorex® Exterior film laminates Processing Guide

te: The information contained within this document is considered recommended guidelines only, to familiarizing our customers with Fluorex® products. Processing parameters for any thermoformed or injection molded part is dependant on the design configuration and materials used in the process. In order to determine the best possible processing conditions, each part will require testing prior to implementation into any production environment

Revised August 20, 2002

Fluorex® exterior film laminates

Table of contents

Materials

1) Description:

Fluorex® exterior film laminate is a fluoropolymer clear / color exterior automotive product on a thermoformable backing, available with an optional decorative finish between the clear & color layers. Topcoats are mechanically and thermally bonded to a thermoplastic substrate, typically ABS or TPO.

This material is typically supplied in roll form and can be slit to meet most width requirements.

The thickness of the sheet is dependent on the type of product selected. Most common grades used for thermoforming and overmolding (ISFxxxx grades) have a total thickness of 23 or 36 mil (0.575mm-0.900mm).

Nomenclature:
Fluorex® ISF2000: clearcoat / colorcoat on 17mil (0.425mm) TPO carrier.
Fluorex® ISF2010: clearcoat / colorcoat on 17mil (0.425mm) ABS carrier.
Fluorex® ISF3000: clearcoat / colorcoat on 30mil (0.750mm) TPO carrier.
Fluorex® T/HR: clearcoat / colorcoat with a Heat Reactive adhesive
Fluorex® A/HR: colorcoat with a Heat Reactive adhesive
Fluorex® Clear/HR: clearcoat with a Heat Reactive adhesive

Note:
Fluorex® T/HR, A/HR and Clear/HR are materials that are generally not suitable for pre-forming and overmolding. This product is normally used to cover another surface (e.g. as a top-layer material in an extrusion lamination process). Technical details of Fluorex T/HR, A/HR and Clear/HR will **not** be discussed in this processing guide.

Product Construction:

ISF Film Construction

Thermoformable Masking Film - 37 to 50 microns, optional
Fluoropolymer Clear Coat - 37 to 50 microns
Color Coat - 37 to 50 microns
Tie Coat and Primer - 20 microns
TPO or ABS bonding layer, thickness specified.

2) Typical properties:

ISF20xx & ISF30xx types have a 17mil and 30mil (0.425 & 0.750mm) ABS* or TPO** backing, and therefore have the tendency to shrink after processing.

Typical shrinkage rates are listed below:

Material	Typical shrinkage (%)	Shrinkage at optimal processing conditions (%)
ABS (17mil/0.425mm)	0.6 – 0.9	0.8
TPO (17mil/0.425mm)	0.5 – 1.0	0.75
TPO (30mil/0.750mm)	0.7 – 1.2	0.9

Shrinkage rates may vary, depending upon part geometry and thermoforming conditions. The temperature of the thermoforming mold has a definite influence on shrinkage rates.

It is essential to measure shrinkage on all applications during the prototype phase, using consistent processing conditions. Maximum shrinkage will be reached after 48Hrs.

The typical use for Fluorex® ISF2000, ISF2010 and ISF3000 is forming in a thermoforming process, followed by an injection molding process (overmolding). Extrusion is also possible.

The ISF30xx (30-mil) TPO material is generally used for relatively larger appliques that require handling stability.

*ABS backing material is an extruded, high surface quality ABS film. The ABS backing is compatible with ABS and PC/ABS injection molding resins.

**TPO backing material, as referenced in this guide, is an extruded film blend or Copolymer of PE, PP, impact modifier and filler. This blend offers the ideal combination of high surface quality, high impact, low thermal expansion and controllable shrinkage. The TPO backing is compatible with PP, EPDM and TPO injection molding resins, including most blends of these products.

Gloss:

Fluorex® ISFxxxx products allow the customer the flexibility of choosing a wide variety of gloss levels from Class A, high-gloss to matte finishes.

Note: In applications where the % area stretch exceeds 100%, the high gloss product is supplied with a thermoformable premask that is designed to prevent the glossdown that generally occurs when Paintfilm is thermoformed. This premask also protects the high gloss finish during subsequent operations (trimming, injection molding, shipping, installation, etc.) and can eliminate the need for a highly polished tool.

The patented Fluorex® basecoat/clearcoat construction consists of a Polyvinylidene Fluoride - Acrylic alloy. This composition provides the optimum balance of properties such as chemical, scratch & mar, and stone chipping resistance as well as excellent resistance to fading or yellowing under UV exposure.

Automotive/exterior grade pigments, metal flakes, and micas are added to the basecoat for matching product color to OEM specifications. In addition to straight shades and metallics, difficult to match pearlescent colors currently used in high end automotive finishes can be replicated as well.

Other Properties:

Fluorex® In-mold paint film is a custom color matched, exterior durable film that meets the demanding specifications of the automotive industry. The fluoropolymer clear coat of Fluorex paint films offer superior weathering, acid rain and chemical resistance as compared to traditional spray-painted surfaces. Fluorex® paint films form a far superior bond to the part surface than sprayed paint, which results in outstanding chip resistance.

Note: For more information on these and other properties, please refer to the individual product data sheets, which can be found on our website at www.paintfilm.com

3) Specifications:

Fluorex® exterior film laminates meet the following specifications (November 1999)

TPO Products:

WSB-M99D61-A2	(Ford)*
MSPH4-1	(Daimler Chrysler)
GM9984141	(GM)
Various	(Honda)
Various	(Toyota)

ABS Products:

WSB-M99D61-A2	(Ford)*
MSPH4-1	(Daimler Chrysler)
GM9984179	(GM)

*Materials without backing are also in use at Volvo.

4) Handling and storage:

Rexam purchases only high quality plastic backing substrates, which are available for the lamination on our dry-paint films.

Material ready for shipment is slit to the required width and length and then coiled onto a standard 6" (152mm) diameter cardboard core. (Other dimensions upon request). TPO backed rolls are wrapped in Polyethylene liners including a unit of silica gel. ABS backed rolls are wrapped in moisture resistant PE/Aluminum liners. All rolls are shipped in cardboard boxes, with the proper supports to prevent damage.

All Fluorex® products should be handled with care and stored on pallets during transport and handling to assure the packaging integrity.

Storage conditions:

Rolls of Fluorex® material should be stored under normal operating conditions. Whenever possible, boxes containing rolls of Fluorex® should be stored in the original packaging to prevent contamination. It is best not to remove the material from the moisture-proof wrap until you are ready to use it and rewrap any unused portion. If stored in a vertical position, rolls should be fully supported on a flat surface.

This material should not be stored outdoors, in places of high humidity or where extreme temperatures can be attained. Temperatures below 0°C (32°F) and over 35°C (95°F) should be avoided. If materials are stored under high humidity conditions (>80%) for extended periods, the substrates can absorb moisture. Under these conditions, pre-drying is necessary to guarantee optimal quality after processing (see below).

NOTE: ABS is much more hygroscopic than TPO, therefore, ISF2010 is more sensitive to moisture absorption than ISF2000 & ISF3000.

Drying conditions: 24-48 hrs in a circulation oven @ 60°C (140°F).

Thermoforming Process

1) Equipment:

Various types of thermoforming equipment can be used to process Fluorex® materials. High quality appliques are best when produced on state of the art equipment in a clean environment. Roll feed thermoforming equipment is preferred. This assures continuity and optimal use of the product. In this process the laminate is unwound from a roll and indexed by a transport system through heating zone(s), over the forming 'table' into the trimming station(s). Thermoforming equipment should preferably be placed in a temperature stable, draft free area, to assure a repeatable, consistent, heating profile.

Since laminate temperature is one of the most critical process parameters, it is important to have adequate control over the heating process. Thermoforming machines should preferably have both top and bottom heating. This will decrease the heating time (cycle time) and improve the quality of the heating, creating a smaller temperature gradient through the product. Multiple, adjustable heating zones are required for the top heater; the bottom heater is less critical.

Note: Most commonly used heating systems can be used. Both IR-C (ceramic) and IR-B (quartz) heaters are most suitable. Heating systems with contact heating, hot air and halogen lights should be avoided for various reasons.

Principle of heating:

Both IR-C (ceramic heaters) and IR-B (quartz heaters) radiate at frequencies where thermoplastics absorb heat. Most plastics absorb very well at frequencies above 2000nm.

Major differences between ceramic and quartz heaters are: *

- The frequency of radiation (wavelength):
  -Quartz heaters radiate between 1500-4000nm, peak emission at 2800nm
  -Ceramic heaters radiate between 3000-9000nm, peak emission at 3800nm
- Reaction and adjusting time:
  When the temperature of a quartz element is adjusted (temperature up or down) it takes 5-8 seconds before the heater element reaches this temperature.
  Ceramic elements need approximately 30-40 seconds to adjust.
- The glow temperature:
  Glow temperature of a quartz element is 1300K, at equal energy consumption, the glow temperature of a ceramic element is 1000K. This results in a ~20% higher irradiation (received energy on a substrate) for quartz, than for ceramic.

* *(Information provided by Philips – The Netherlands)*

All this information together may lead to a preferred choice for quartz heating elements over ceramic heating elements; however, excellent results have been obtained with thermoforming machines equipped with ceramic heaters.

Laminates, when formed on the roll, are preferably pre-heated in multiple heating zones. This will provide a smoother heating profile and reduce the cycle time. Approximately 20-40 seconds of heating time or 2-4 indexes of material should be sufficient for heating of the laminate depending on product thickness.

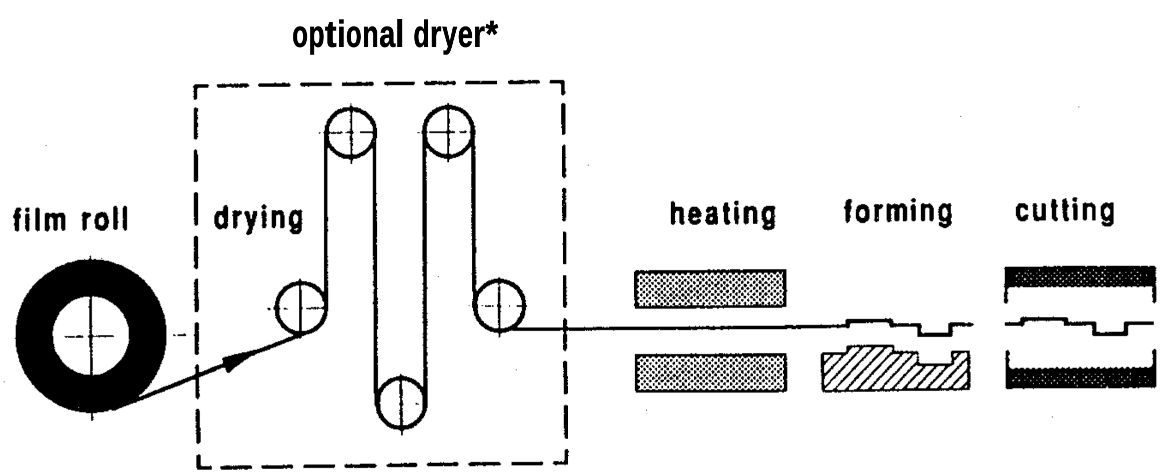
The forming station should be provided with upper and lower platens having specific dimension and stroke, to allow for various molds in the machine. Preferably, the machine should have the option for overpressure during forming.

In the case of large, ‘deep’ tools (e.g. fascia tools) the clamping frame should have adjustable moving parts to allow for ‘wrap’ of the film partly over the tool to prevent very high elongation. These types of machines and molds are better purchased for a specific tool/mold and not for general use with multiple molds.

High quality appliques can only be made when the thermoforming tool (mold) is heated, (see section 2).

Fluorex® laminates require quenching directly after forming which can be done either with an auxiliary air conditioning unit (e.g. a fan blowing cold air) or with a second tool that is temperature controlled.

A trimming station can also be a part of the machine or system. Directly after the forming step a rough trim can be made. A reliable vacuum system should also be part of the system.



Continuous vacuumforming process

*Drying is only necessary when the backing sheet contains excessive moisture.

2) Thermoforming Mold:

Fluorex® exterior film laminate is normally formed over a male mold with the backing side contacting the mold, the decorated side (read 'paint') should not be in contact with any surfaces.

Most molds are constructed of cast aluminum due to its excellent heat transfer rate. For small runs or prototyping, molds can be made of wood or epoxy, which are an inexpensive and quick solution, and ideal for producing a limited number of samples.

A **cooling/heating** system in the mold is an essential part of the construction. A consistent mold surface temperature is required to obtain the best results. The most frequently used cooling/heating medium is water, (connected to a heater pump), however, electrical heating/cooling systems are also used.

Vacuum holes are needed to make a 'sharp' applique. The holes should be drilled in the mold on critical lines/spots. Typical vacuum hole dimensions are 0.015" – 0.035" (0.4-0.8mm) (outer diameter). The vacuum holes are an essential part of the design and should therefore be placed very carefully. The number and location of the vacuum holes will vary depending on the dimensions and geometry of the part. Slot venting that allows peripheral vacuum around the part is also essential. (Porous steels and other methods of obtaining vacuum can also be used).
The mold surface should be rough enough to allow vacuum, but smooth enough to show no surface defects. A surface 400-grit finish is normally acceptable to cope with both items. The tool should be sandblasted to facilitate release and draw down during the process.
The fit of the applique (preform) in the injection mold is essential in obtaining high quality products. Therefore it is necessary to determine the exact dimensions of the injection mold surface (using CAD data or an epoxy cast).

Allowance for the laminate thickness and shrinkage must be taken into account. The thermoform mold should be sized in accordance with the shrinkage of the film backing sheet material. The shrinkage value can vary with the amount and type of orientation in the sheet when formed. The final part shrinkage can also vary with mold temperature (the hotter the mold, the more shrinkage), the length of time on the mold, and variation in the melt index of the sheet material. These factors must all be taken into consideration.

The vacuum mold should be of such a shape that elongation of the film is minimized and undercuts are avoided (when possible). Weld-lines on the tool can cause lines (wrinkles) and should be avoided when possible. The recommended draft angle (for ease of forming and release) is 4 to 6 degrees.

The ideal mold temperature is hard to define, but a temperature of approx. 35°-45°C (95°-110°F) is a good starting point. This should prevent immediate 'freezing' of the laminate as soon as the laminate hits the tool and help to reduce shrinkage.

3) Trimming:

Trimming of the applique (preform) can be accomplished in-line with the thermoforming process or in a separate operation following the thermoforming step.

There are several processes suitable for trimming an applique:

A) Cutting with a mechanical or hydro-mechanical die-trimming press
B) Waterjet cutting
C) Laser cutting
D) Die-mill cutting

All of the above mentioned trimming systems have their advantages and disadvantages, depending on the part geometry, equipment and in-house experience.

Method **A** is most commonly used. High quality cutting dies are necessary in order to achieve the precision required and to avoid damaging the applique or introducing cuttings/clippings from the trimming operation, which can contaminate the surface.

The most cost-effective method is in-line cutting, -directly after forming, - however, this is not possible in all cases.

Depending on the part geometry, both vertical and horizontal cuts may be required and more than one trimming step may be needed. In this case, only rough trimming is possible in-line. Precision cutting has to be accomplished later.

The key to accurate, quality trimming is also attributable to the holding fixtures used. Well designed, substantial trim fixtures are always an advantage.

4) Applique handling recommendations:

Once a laminate is formed and trimmed, one must take care that the applique is not damaged or the surface is not contaminated with dust, dirt or trimming scraps.

To avoid surface damage we recommend the following operations:

- Cover all sharp objects in the room where appliques are handled.
- Do not pile appliques on top of each other (‘nest’) without soft tissue or cloth between each part.
- Have all personnel wear soft or latex gloves.
- Avoid sharp objects on the clothing of the personnel (watches, buckles etc.)

To avoid dust pick-up or contamination we recommend the following:

- Exhaust and chip removal systems are definitely an advantage.
- The use of an antistatic agent and/or antistatic bar or ionized air and/or conductive bristles will eliminate dust and dirt problems prior to loading in the injection-molding machine.
- Keep the handling and storage rooms in an overpressure condition (Hepa filtrated air)
- Put ‘nested’ appliques in plastic bags, and limit the amount of appliques in a nest.
- Do not pack appliques in raw cardboard boxes (Dust !)
- Pack the appliques in such a way, in the containers that movement is eliminated.
- Personnel should be aware and be careful about bringing in dust or contamination via clothing and hair.

5) Thermoform Process conditions:

Fluorex® TPO Material:

Ideal laminate temperature	130°C-150°C / 265°F-305°F
Maximum laminate temperature	160°C-165°C / 320°F-330°F
Vacuum mold temperature	35°C - 40°C / 95°F-105°F

Fluorex® ABS Material

Ideal laminate temperature	140°C-160°C / 285°F-320°F
Maximum laminate temperature	170°C-175°C / 340°F-350°F
Vacuum mold temperature	35°C - 40°C / 95°F-105°F

6) Troubleshooting for Thermoforming:

Problem	Description	Cause / Correction
Gloss too high	Gloss higher than specified	Laminate surface temp. too high - Decrease the temp. of the top heater - Increase temp. of the bottom heater
Gloss too low	Gloss lower than specified	Laminate surface temp. too low -Increase the temp of the top heater -Decrease temp. of bottom heater
Die Back	Loss of DOI/gloss (especially visible after forming of metallics)	Laminate temperature too high -See above Extreme elongation/thinning of laminate Mold temperature too high
Blushing	Change in color	Insufficient or excess heating of sheet Mold too cold or too hot Sheet being stretched too far Depth of draw too deep for sheet thickness Sheet may be cooling before it is completely formed
Whitening of sheet	White stretch marks appear on sheet or part	Cold sheet stretching beyond its temperature yield point -Increase heat of sheet; increase speed of drape & vacuum A hot air gun may be used to diminish or eliminate whitened surfaces on formed parts.
Blisters / Bubbles	Top surface shows blisters	Laminate temperature far too high -lower both top and bottom heater Laminate contains moisture -not properly stored (moisture absorption) -dry properly (see sect. 4: storage) Heating sheet too rapidly or unevenly -check heaters from both sides
Bumps	Spot(s) on applique surface	If the bump contains dirt; -Stop process and clean tool -Clean vac. form tool on regular basis -Check surface of vac. form tool for defects Small bumps (<1mm) which are clean; usually disappear after overmolding

Troubleshooting for thermoforming -continued-

Problem	Description	Cause / Correction
Pits / Dimples	A depression in applique surface	Check surface of vac-form tool for defects. -Stop process and repair tool Small pits/dimples (<1mm) will disappear while overmolding.
Freeze line	Laminate freezes on parts of the tool before forming is completed	Commonly with high gloss laminates: -Sandblast tool surface -Increase tool temp. -Increase vacuum (pull down speed) -Increase laminate temperature -Work with plug-assist Smooth the tool surface for ease of forming (e.g. talcum powder)
Webs/folds/wrinkles	Lines/folds on appliques, especially in corners	Temperature too high Lower temp./ shorter heating time Add a 'film consuming' block close to the creased corner, this to stretch the film more locally. Insufficient Vacuum pressure or holes Insufficient draft angle Check for sufficient radii
Too much sag	Sheet sagging during heating and not drawing back up	Sheet too hot – reduce heat or cycle time Uneven sheet heating
'Vague' formed part	Applique was not deep drawn in sharp shapes	Laminate temp too low - increase temp / longer heating time Increase mold temp Check vacuum system for leakage, obstructions etc. Check vacuum holes for obstructions Vacuum not drawn fast enough -check vacuum pressure Surface of tool too smooth, sandblast the tool (400 grit) Check for uniformity of heat
Tearing	Tearing of sheet when forming	Mold design (increase radius of corners) Sheet too hot or too cold

Troubleshooting for thermoforming -continued-

Scorching	Sheet appears scorched	Outer surface of sheet too hot -Shorten heat cycle -Use slower, soaking heat (lower) -Move heater bands further from sheet
Poor wall thickness distribution	Excessive thinning or holes in some areas when sheet is stretched	Improper sheet sag Hot or cold spots in sheet -Check heating technique -Check to see if all heating elements are functioning. Sheet too thin – use thicker material stock.
Excessive Shrinkage	Shrinking of applique'after removing from mold	Removed from mold too soon -Increase cooling cycle -Use cool air blow off with fan Check sheet orientation
Part Warpage	Distortion of applique'after removing from mold	Mold temperature too low Uneven part cooling Poor wall distribution due to uneven sheet heating Poor mold design -check vacuum holes or add more -add moat to mold at trim line
Part sticking to mold	Difficult to remove part from mold	Mold or sheet temp. too high Not enough draft angle in mold Mold undercuts present -use stripping frame -increase air-eject pressure Part left on mold too long after Quenching
"Puddles"or bad surface markings	Air inclusions between applique and tool	Check vacuum system for leaks / obstructions. Surface of tool too smooth, sandblast the tool (400 grid) If puddles are localized: roughen the surface with sandpaper (400) in one direction (towards vacuum holes)

Injection Molding Process

1) Equipment:

No special type of molding machine or equipment is needed to make overmoldings with a paintfilm applique. In any case, the user must provide a clean environment, (in and around the molding machine), since dust and other static ‘irregularities’ are one of the greatest causes of rejects.

Clean the appliques before putting them in the mold, (e.g. with ionized air, an antistatic agent and/or conductive bristles). It is similar to overmolding of other IMD materials. The trimmed applique should fit perfectly in the mold cavity. The decorated (painted) side is placed against the polished injection mold surface. Accurate positioning is an essential part of the job. The final shrinkage of the applique is reached after a period of 48 hrs. It is recommended not to overmold the applique before that time.

There are four (4) different methods for positioning the applique depending on shape and geometry: friction, static adhesion, vacuum and tabs on the applique.

- Friction can be achieved by using slightly oversized appliques.
- Static adhesion (ionization) is often used for flat films.
- Vacuum makes use of tiny holes (0.05mm max) or porous steel to keep the applique in the correct position.
- With tabs, pins can be added in the mold, right next to the cavity. A tab with a hole on the applique enables the applique to fit properly and stay in position.

The mold can be closed and the applique can be overmolded with a compatible resin. Heat and pressure during the injection step create a melt bonding between the applique and the resin, forming a finished ready-to-use part.

Cooling and releasing from the mold are the same as for any injection-molded parts. Depending on the geometry and the gating system, secondary operations such as trimming of gates and runners may be necessary.

A minimum total part wall thickness of approx. 100-120 mils (2.5-3.0mm) (resin + applique) should be maintained for a good combination of mechanical quality and cosmetic look of the part. Sufficient space in a mold-open position must be available for insertion and removal of appliques and finished parts, to minimize the chance of damage.

Robotic equipment for loading the appliques in the mold is preferred over manual handling. Speed and precision positioning are the biggest advantages over manual handling. In most cases the robot which is used to remove finished parts can be adapted to load appliques. Robots can limit handling cycle time to as little as 3-5 seconds.

A highly polished mold surface in a clean environment will yield the best quality parts. Disturbances on the mold surface are duplicated in the film surface because of the high pressure during the injection molding process.

A high quality hardened steel mold with a highly polished surface (1000-1200 diamond polish) is recommended. Nickel or chrome plating of the cavity surface may not be necessary.

Highly polished tools will produce high quality parts.

Process Parameters:

Follow the normal resin supplier recommendations for injection molding conditions, and dry the resin accordingly. Keep in mind that you are replacing a part of the resin by a film and the injection pressure will be lower in the mold cavity. You may need to adjust the injection speed and/or pressure to fill the tool properly, however, too high injection speeds or pressures should be avoided.

Temperature behavior will also be different; the film which is set in one side of the mold, will act as an insulator. This will have an effect both during injection and cooling cycles.

During the injection phase, freezing of the resin against the film will be slower than against the mold, resulting in better flow and longer flowlength regardless of the thinner wall.

During the cooling phase, cooling the resin will not be as effective since the film will insulate the relatively low mold temperature, resulting sometimes in longer cooling times.

When the application is relatively large, sequential molding/cascade molding is preferred over traditional injection systems. Sequential molding will reduce the possibility of weld lines. Weld lines can become visible during the injection phase. The film is slightly elongated from more directions, and at the weld line there is an excess of material which will result in a wrinkle.

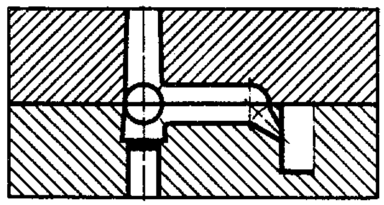
Mold/Tool Temperatures:

Film side -	35°C - 40°C / 95°F - 105°F
Non-Film side -	As recommended by the resin supplier

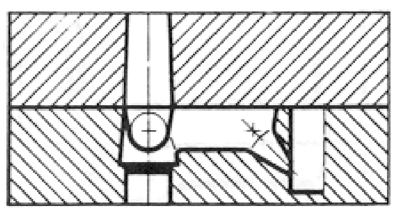
2) Runners & Gates:

Runners

Runners should be generous. The diameter determines friction, thus flow and extra heat, and for that reason a full round primary runner of minimal 5mm diameter is recommended. Runners should be kept as short as possible and hot runner systems are advised for long melt flows in the mold. Cold slug wells should be included at the end of the secondary runners.



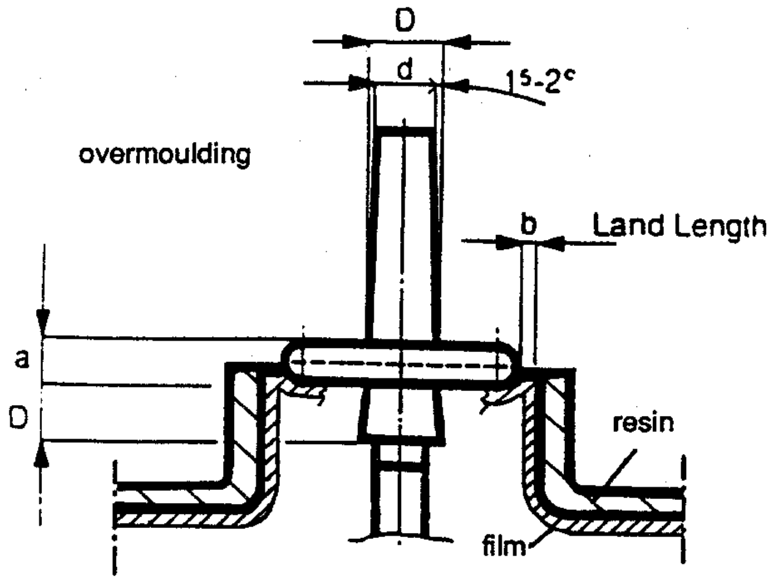
Try to avoid half round runners that are often seen on the parting line. Half round runners can cause problems, since they give the least amount of flow combined with high chilling of the resin flow. Trapezoidal runners, provide a balance between full and half round.



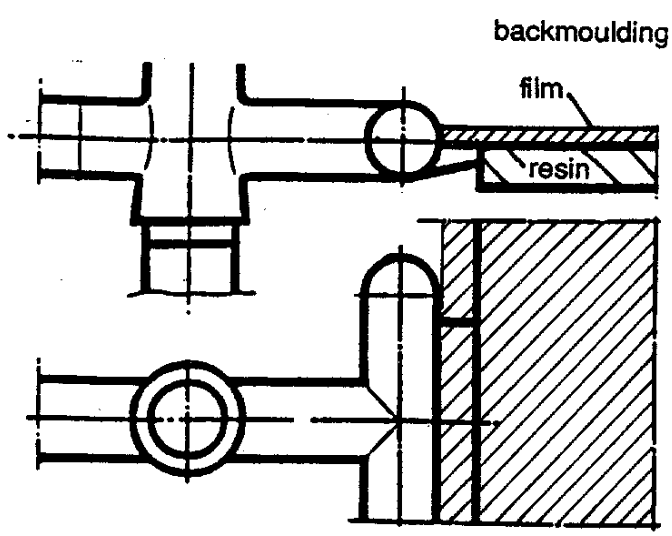
Part Gating:

Numerous gating types are used in injection molding, however only a few of them can be recommended for IMD.

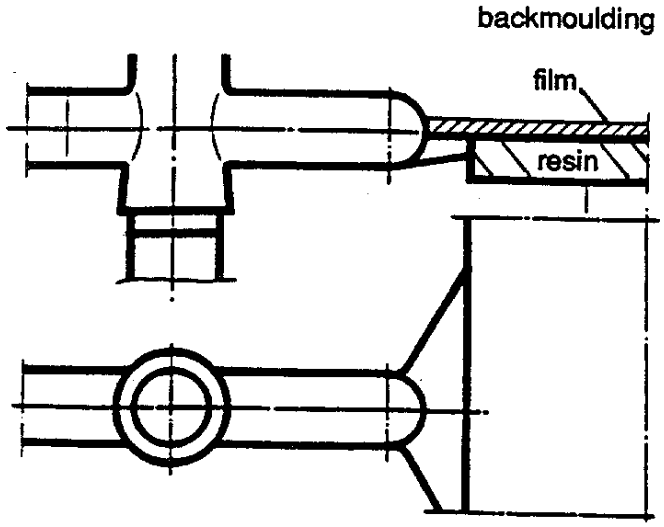
1. **Diaphragm gating:** This is used to obtain good concentricity and a high weld line strength while molding cylindrical products. A maximum land-length of 0.5-1mm is recommended.



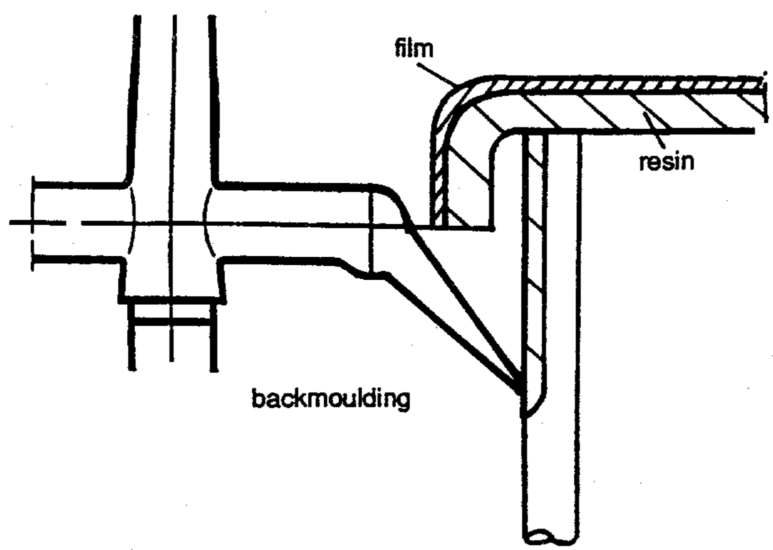
2. **Film gating:** This is used where flat designs or large areas are molded with a minimum warpage. Film gating can be considered an elongation of a fan-gate.



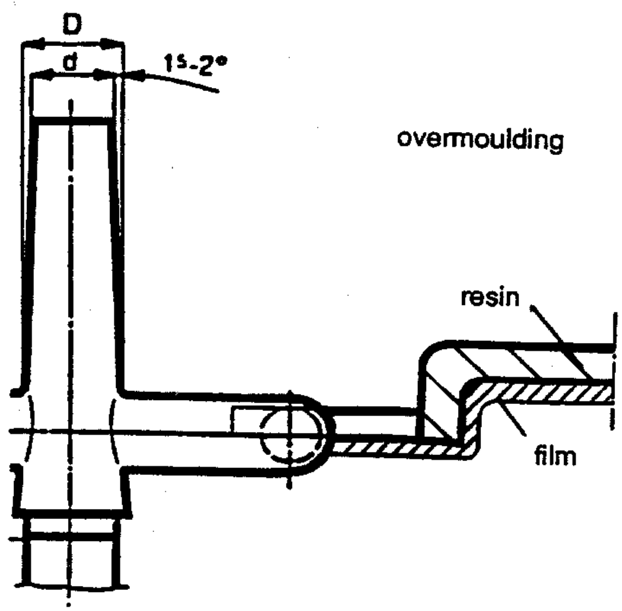
3. **Fan gating:** Fan's are a special type of edge gate, used to feed flat, thin sections, which spreads the material flow uniformly across the cavity. Typically used for rectangular parts.



4. **Tunnel gating:** Enables automatic de-gating of a part of the runner system during ejection. Recommended diameters are >1mm.



5. **Tab gating:** Tabs are used for flat parts; they can reduce gate blush and residual stress in the gate area.



6. **Hot runner gates:** The most preferred method is the hot runner tip on a non-visible area of the part. Especially with relatively large parts where sequencial injection – molding should be used, a hot runner system offers the greatest advantages.

7. **Direct gating:** This is not the ideal option, however, when the design freedom is limited, directly gating on the surface of the application, may be the only option. In this case, hot runner gates are preferred over other direct gating. The chance of sinkmarks visible at the film surface is minimized using hot-runner gates. A local thinning of the wall thickness can be an option to reduce surface defects even more.

The exact choice of gate type is dependent on shape and geometry of the application. In any case one should consider the following:

- An impinging gate ensures that the incoming resin is directed against the cavity wall or core (read 'applique'). This will help to avoid jetting.
- The gate should direct air towards the vents, to avoid trapped gas.
- The gate should be located in such way that the resin flow goes from thick to thin.
- The gate position should minimize or eliminate weld lines.
- Stressed areas should be avoided.
- One should seriously consider the ease of degating afterwards.
- Direct gating is preferred for thick wall applications.
- Accurate nozzle geometry and relatively slow injection speeds will reduce problems such as injection through the film.

It is recommended to introduce the hot melt directly onto the applique back surface and not over the edge of the applique. This will help to insure that the molten resin does not flow onto the visible side of the applique.

3) Finished part handling:

As with all decorated or painted surfaces, one must take care in handling the finished parts in order to avoid damage of the finished surface, leading to repair or reject.

Whenever possible robot part removal is recommended over manual handling, to minimize rejects, and to maximize efficiency of the overmolding process.

Again, it is important to be careful of sharp objects in and around the area that could scratch or damage the parts. Personnel should wear soft or latex gloves.

Secondary operations such as removal of runners, gates or other parts, adding snap-fits or other items should be done with great care.

Nesting of finished parts should also be done with care, placing soft tissue or cloth between the parts. We recommend not more than 10 parts in a nest. Plastic bags are preferably used to pack the nests, prior to packaging in a box or container. Packaging in boxes or containers should be done in such a way that movement of the parts is minimized. This way the least damage from touching each other will occur.

Storage is recommended in a dry room where temperatures are not excessively high or low (10-30°C / 50-86°F). The final shrinkage of the part is reached after a period of 48 hrs. It is recommended not to fix the part onto the final product before that time.

4) Trouble shooting (injection molding):

Problem	Description	Cause / Correction
Blow out & weld-lines	Resin material on the surface or a hole in the shell	Applique does not fit well in cavity -check match of vac form mold dimensions to injection mold tool Applique not in optimal position Applique twisted in the cavity Gating area may be incorrectly placed Too high injection speed/pressure Poor trim quality *Above mentioned problems are hard to solve, in most cases the quality of the applique can be improved. Changes in gates and other mold related items are difficult.*
Dirt & Pits	Impressions on the surface	Dirt on the applique or on the injection molding tool. -clean mold on regular basis with ionized air -clean appliques before loading -check housekeeping, work in a clean environment
Paint film fails to adhere to plastic	Film not sticking to part after injection molding	Insufficient cure time Melt temperature too low Non-compatible molding resin used
Die Back	Loss of gloss / DOI	Temperature of mold surface too low -raise mold temp to min.50°C (120°F) Mold surface too rough -polish surface to a 1200-diamond polish, or coat the surface.
Wrinkles	Visible line on surface	Applique too large/Poor applique quality -check mold design/dimensions Severe elongation of applique caused by too hot resin: wrinkle on the weldline When the applique comes over the parting line of the mold, the applique gets folded during closing. Applique does not touch the cavity surface everywhere Check pre-trim of appliques for interference in injection mold

Trouble shooting for injection molding -continued-

Loss of Gloss in Paint film	Dulling in film surface	Dwell time too long, shorten
String lines	A ‘hair’ on the surface	Leaking sprue, leaving a resin ‘hair’ during opening of the mold. This hair will leave in impression on the next part -adjust resin temperature -repair leaking nozzle
Burns	Burn mark on part	Entrapped gas during injection -clean vents -Too high injection speed -Too high temperatures (resin and tool)

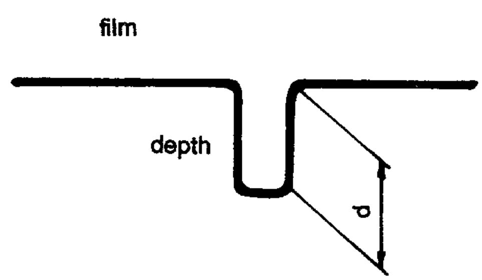
Design Considerations

The mold design should always be 'film friendly'. In other words, is the part geometry suitable for an IMD process? Many problems can occur when the part geometry is not "film friendly", or when, because of the geometry, trimming is difficult.

Items that can cause severe problems are listed below:

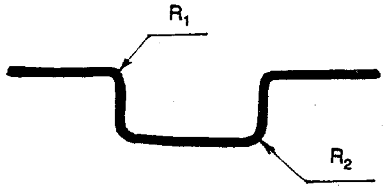
- 2 or more deep draws next to each other (see figure A & C)
- 'Pockets' in the part
- Multiple undercuts
- Extreme elongation, locally or all over the part
- Too sharp edges (too small radius on edges) (see figure B)
    - Top side of film $\geq$ 2 x film thickness
    - Bottom side of film $\geq$ 4 x film thickness
- Inconsistent wall thickness
- Weld lines in the molded part combined with 'normal' (not sequential) molding
- Parting line of the tool on the 'wrong' side of the part
- Very small direct gated (hotrunner) sprues
- Thin part (<2.5 mm), in combination with long flow lines
- Moving cores to create holes in the part
- Large, direct gates on the visible (front) side of the part

In many cases an existing tool may need adjustment to make overmolding possible. This can vary from minor changes to a total re-design of the mold.



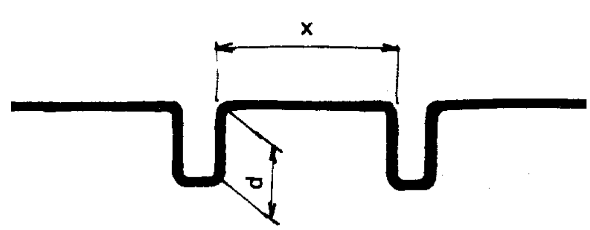
d = 10 x film thickness

Figure A



$R_1 \geq$ film thickness $R_2 \geq$ 4 x film thickness

Figure B



$x \geq 2d$

Figure C

Glossary of Abbreviations

ABS:	Acrylonitrile Butadiene Styrene
TPO:	Thermoplastic Olefin
PP:	Polypropylene
PE:	Polyethylene
EPDM:	Ethylene-propylene-diene rubber
PC:	Polycarbonate
HR:	Heat Reactive
Preform:	Thermoformed film part, not trimmed
Applique:	Preformed trimmed film part.
DOI:	Distinctness of Image
Die Back:	Loss of gloss and DOI after pre-forming or injection molding
IMD:	In-Mold Decoration
°C:	Temperature in Centigrade
°F:	Temperature in Fahrenheit

For more information contact:

In the U.S.:

Soliant LLC
Attention: Product Manager
1872 Highway 9 Bypass
Lancaster, SCC USA 29720
803 313 8227
803 313 8227 (FAX)

In Europe:

Soliant LLC
Keulenstraat 1
NL-7418 ET Deventer
The Netherlands
31 570 605 042
31 570 605 020 (FAX)

Or visit our web site at: www.paintfilm.com