EUROPLEX®

EUROPLEX®
Thermoforming & Fabrication Guide

About EUROPLEX®

EUROPLEX® is a transportation interior grade sheet available in a range of opaque and transparent colors offering impressive heat release properties and smoke, flame and toxicity compliance. Added advantages include low weight, low processing temperatures, excellent ductility and availability in a variety of colors.

Save time: Full compliance to FST and heat release requirements for transportation applications, eliminates the need to spend extra time obtaining waivers and other product approvals.

Save weight: With a density of 1.20 for polycarb-based sheets and 1.39 for PPSU sheets, EUROPLEX® products provide critical weight savings. Every kg of weight removed from an aircraft or railcar can provide substantial fuel savings each year.

Save costs while increasing design freedom: EUROPLEX® provides increased design freedom because it is capable of being formed into complex application shapes that feature deep cavities, thin walls and combinations of sharp or soft angles.

EUROPLEX® is an ideal choice for both large and small components throughout an interior:

- Seats
- Tables & trays
- Fuselage wall & ceiling covers
- Window surrounds

- Door frames
- Lighting covers
- Cockpit linings
- Partitions

- Cargo and overhead compartments
- Galleys & serving trolleys
- Emergency lighting systems

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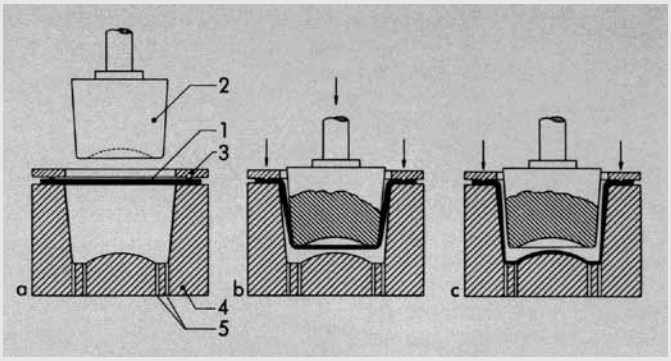
EUROPLEX® Product	Optical Property	Heat Release Compliant	FST Toxicity Compliance	Specific Gravity	Colorability
Aircraft					
F3	Opaque	No	Compliant	1,23	Excellent
F6	Light scattering	No	Compliant	1,21	N.A.
F7	Clear	No	Compliant	1,20	N.A.
F10	Opaque	65 / 65	Compliant	1,30	Good
PPSU Opaque	Opaque	65 / 65	Compliant	1,39	Good
PPSU Clear	Clear	65 / 65	Compliant	1,29	N.A.
Railway					
R 99775	Opaque	MARHE	Compliant	1,39	Good
R 99325	Opaque	MARHE	Compliant	1,37	Good
F8	Opaque	No	Compliant	1,23	Excellent

The Thermoforming Process

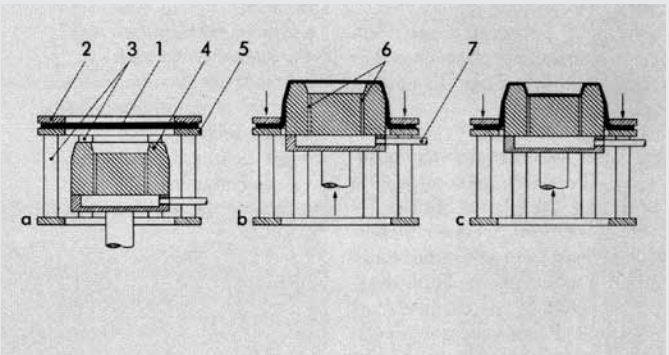
Designers appreciate the freedom offered by thermoforming. The established process provides a designer with the opportunity to create complex shapes and forms that feature cost/performance charac teristics. Thermoforming has significant advantages over more traditional methods of production. Low cost tooling, large part production and reduced lead times all contribute to the advantages of producing shapes with the thermoforming process.

Thermoforming requires heating a plastic sheet to its softening temperature and then drawing the soft material over or into a mold using either a vacuum or air pressure method. When the part has taken on the shape of the mold, it is then allowed to cool, and is finally removed from the mold. Using heated positive air allows much higher pressures and can result in sharper details.

EUROPLEX® sheets can be easily thermoformed to feature sharp detail on any conventional forming equipment that is capable of quickly transferring the sheet from the heating station to the mold or forming table. Rapid transfer is required because the sheets cool quickly and become form-stable at a higher temperature than other materials. Although double-oven automatic or semi-automatic forming equipment is recommended for EUROPLEX® sheets, single-sided heating canopy-type equipment can be used.



Vacuum-forming into a female mold with mechanical pre-stretching. EUROPLEX® (1), plug (2), clamping frame (3), female mold (4), suction ducts (5)



Vacuum-forming onto a male mold with mechanical pre-stretching. EUROPLEX® (1), clamping frame (2), supporting tubes (3), male mold (4), mold frame (5), suction ducts (6)

An Important First Step: Pre-Drying the Sheets

Always pre-dry EUROPLEX® sheets prior to vacuum forming. Small amounts of moisture absorbed in storage or shipment can cause moisture bubbles, loss of forming detail and visually unattractive surfaces.

For pre-drying sheets, use a vented, air circulation oven. Place the sheets vertically in the oven, or on racks that provide a minimum separation of 2.5 cm between sheets. When a sheet has been dried, it may be used for up to 12 hours without repeating pre-drying, depending on environmental conditions. When using automatic equipment, cool the sheet to room temperature to maintain uniform cycles. Remove any protective masking before pre-drying.

Clamping Frames

Place the pre-dried sheet in machine clamping frames capable of exerting sufficient force to prevent the sheet from pulling out during forming. The frame should also provide some stripping action as the formed part is removed from the tool. The mass of the metal clamp frames can cause a substantial difference in sheet temperature between the relatively cool edges of the sheet and the heated center. Clamping frames should allow maximum temperature build-up in the sheet under the clamp.

Always preheat the clamp frames to the sheet thermoforming temperature and maintain them at this temperature. It is common to paint clamp frames black to maximize radiant heating of the frames. If small individually controlled heating elements are not available, shading is sometimes used on the center portion of the sheet to enable faster heating of the clamp and sheet edges. Heaters may also be put in the clamps themselves.

Forming the Sheets and Removing the Formed Part

When EUROPLEX® sheets reach forming temperature, bring it down over the tooling and apply vacuum. EUROPLEX® sheets set up very quickly, permitting a much shorter cycle than is possible with most other materials. Remove the formed part from the mold as soon as the material is form-stable and still hot to the touch. Avoid stress build-up and difficult removal due to post mold shrinkage by removing the part from the tool when the part temperature reaches the required forming temperature. If possible, perform the trimming operation while the part is still warm to minimize flange warpage.

Retaining Texture During Thermoforming

To preserve the fine texture on EUROPLEX® sheets, keep the sheet surface temperature on the textured side at a lower level. During the forming process, profiling the vacuum forming ovens can be beneficial. The heaters that directly impinge on the textured surface should be set to a lower output than the bottom side oven. For example: top heater output set at 25 % and bottom heaters to 77 or 75 % is a good starting point. If these settings increase the forming cycle time to an unacceptable level, try increasing the bottom heaters to 90 % or higher.

Troubleshooting

Blue spots

- Spots form at elevated temperatures due to the combination of TiO2 in the formulation of light colored sheets combined with the presence of organic fiber, such as polyester fibers from clothes or paper towels that may have been used for cleaning.

Reason:

- TiO2 is a heat conductor facilitating organic fiber
- decomposition
- Trace amount of organic fiber impurities are not detected by conventional analytical techniques

Recommendations for Minimizing Spots:

- Clean surface thoroughly before forming, use deionized pressured air
- Minimize forming temperatures if possible

EUROPLEX® Product	Pre-Drying Temperature °C / Time	Sheet Forming Temperature °C	Tool Temperature °C	Mold Shrink (dep. on temp & type)
Aircraft				
F3	115 / 2 hours per mm	180 – 200	80 – 120	0,8 – 0,9 %
F6	115 / 2 hours per mm	180 – 200	80 – 120	0,9 %
F7	115 / 2 hours per mm	180 – 200	80 – 120	0,9 %
F10	115 / 2 hours per mm	180 – 190	80 – 120	0,7 – 0,8 %
PPSU Opaque	175 / 4 hours per mm	260 – 290	150 - 180	0,8 – 1,0 %
PPSU Clear	175 / 4 hours per mm	260 – 290	150 - 180	0,8 – 1,0 %
Railway				
R 99775	175 / 4 hours per mm	260 – 280	150 - 180	0,8 – 1,0 %
R 99325	175 / 4 hours per mm	260 – 280	150 - 180	0,8 – 1,0 %
F8	115 / 2 hours per mm	180 – 200	80 – 120	0,8 – 0,9 %

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Problem	Possible Causes	Suggested Solutions: For Polycarb Sheets	Suggested Solutions: For PPSU Sheets
Voids or Bubbles in Formed Parts	• Excessive moisture in sheet	Dry as recommended. 115 °C for 2 hours per mm of thickness with minimum separation of 25 mm between sheets.	Dry as recommended. 175 °C for 4 hours per mm of thickness with minimum separation of 25 mm between sheets.
Crazed or Brittle Parts	• Mold design • Part left on mold to long • The use of incompatible mold lubricants	Mold radii should be at least the thickness of material. Remove part from mold as soon as it becomes form stable. Use compatible powdered mold release.	Mold radii should be at least the thickness of material. Remove part from mold as soon as it becomes form stable. Use compatible powdered mold release.
Part Warpage	• Mold to cold • Clamp frames too cold • Part left on mold too long	Preheat mold 80 – 120 °C. Preheat clamp frames to 120°C Remove part from mold as soon as it becomes form stable.	Preheat mold 150 – 180 °C. Preheat clamp frames to 150 °C Remove part from mold as soon as it becomes form stable.
Non-Uniform Drape	• Uneven heating of sheet	Check heater section and adjust. Use selective screening if necessary. Check for cold air drafts.	Check heater section and adjust. Use selective screening if necessary. Check for cold air drafts.
Difficult Part Removal	• Insufficient draft angle mold undercuts • Mold finish perpendicular to direction of part removal • Ejection pressure too low	Increase draft angle. Use strip rings or cam action mold. Resurface mold. Sand mold sides vertically. Add air holes, increase injection pressure. Use powdered mold release.	Increase draft angle. Use strip rings or cam action mold. Resurface mold. Sand mold sides vertically. Add air holes, increase injection pressure. Use powdered mold release.
Poor Surface Finish	• Mold surface too rough • Mold mark-off • Draft angle	Draw-polish mold or use different mold material. Use silicone or powdered mold lubricant sparingly. Increase draft angle.	Draw-polish mold or use different mold material. Use silicone or powdered mold lubricant sparingly. Increase draft angle.
Insufficient Draw Down Poor Definition	• Improper sheet heating • Insufficient vacuum • Poor mold design	Increase heating time and temperature. Check vacuum system for leakage. Add more vacuum holes. Check for good seal between clamp frames and vacuum box.	Increase heating time and temperature. Check vacuum system for leakage. Add more vacuum holes. Check for good seal between clamp frames and vacuum box.
Webbing or Bridging	• Improper mold layout • Blank too large for mold • Material overheated • Improper mold design • Vacuum rate too fast	Increase spacing between molds. Use grid or ring assist. Leave a minimum of material around the mold. 50 mm is a good rule of thumb. Shorten heat cycles. Increase radii and draft angle. Slow down vacuum rate (use smaller vacuum holes). Restrict main vacuum lines.	Increase spacing between molds. Use grid or ring assist. Leave a minimum of material around the mold. 50 mm is a good rule of thumb. Shorten heat cycles. Increase radii and draft angle. Slow down vacuum rate (use smaller vacuum holes). Restrict main vacuum lines.
Chill Marks	• Mold too cold • Insufficient draft angle and radii	Mold should be heated 80 – 120 °C. Increase mold radii and draft angles.	Mold should be heated 150 – 180 °C. Increase mold radii and draft angles.
Loss of Vacuum Seal	• Cold clamp frames • Improper spacing between clamp frames & vacuum box	Preheat clamp frames 120 °C. Minimum space between clamps and vacuum box 13 to 19 mm.	Preheat clamp frames 150 °C. Minimum space between clamps and vacuum box 13 to 19 mm.
Material Pulling Out of Frames	• Insufficient clamp area • Inadequate clamp pressure • Uneven heating	Adjust clamp points uniformly at sheet perimeter. Increase clamp pressure to maximum. Control sheet temperature. Use center screening to allow more heat at sheet perimeter.	Adjust clamp points uniformly at sheet perime-ter. Increase clamp pressure to maximum. Control sheet temperature. Use center screening to allow more heat at sheet perimeter.
Excess Thinning Severe Necking Poor Surface Finish	• Drape speed too fast • Improper forming temperature • Mold design • Incorrect forming technique	Set drape speed to not exceed 125 mm per second. Ideal forming temperature 180 – 200 °C. Increase upper radii. Try snapback or billow-forming techniques.	Set drape speed to not exceed 125 mm per second. Ideal forming temperature 260 – 290 °C. Increase upper radii. Try snapback or billow-forming techniques.

Problem	Possible Causes	Suggested Solutions: For Polycarb Sheets	Suggested Solutions: For PPSU Sheets
Uneven Material Distribution	• Excess thickness variation • Uneven heating • Non-uniform clamp pressure • Improper forming technique	Check gauge tolerances. Check uniformity of heater output. Screen if necessary. Maintain uniform clamp pressure to avoid pull-out. Use billow or snapback forming method.	Check gauge tolerances. Check uniformity of heater output. Screen if necessary. Maintain uniform clamp pressure to avoid pull-out. Use billow or snapback forming method.
Wrinkles on Flat Horizontal Surfaces	• Uneven cooling due to slow drape speed • Material is too hot (too much sag or drape)	Drape at higher speed 173 mm /second. Screen center of sheet allowing edges to heat first. Use taller vacuum box to provide more pull by area.	Drape at higher speed 173 mm /second. Screen center of sheet allowing edges to heat first. Use taller vacuum box to provide more pull by area.
Texture Wash-out and Excess Gloss	• Forming temperature too high • Improper heating technique	Reduce heater inputs and cycle time. Heat sheet from smooth side. Keep texture cool.	Reduce heater inputs and cycle time. Heat sheet from smooth side. Keep texture cool.
Pinholing or Pimples	• Vacuum holes too large • Dust on mold or sheet • Mold too cold/too smooth surface finish • Vacuum rate too high	Use 50-mil (1.25 mm) holes or smaller. Clean mold and sheet with deionizing air gun. Keep mold temperature at 80 – 120 °C. Sand mold surface with medium grit paper. Place small orifice over main vacuum holes.	Use 50-mil (1.25 mm) holes or smaller. Clean mold and sheet with deionizing air gun. Keep mold temperature at 150 – 180 °C. Sand mold surface with medium grit paper. Place small orifice over main vacuum holes.

Designing Your Mold

Mold Materials

Internally heated cast or machined aluminum molds have been successfully used with EUROPLEX® and are suggested for long production runs and parts that require fine, small areas of definition. Small pro-duction runs and prototype parts can be produced using woods, metal filled epoxy and other similar materials allowing for inexpensive prototyping an tooling modifications if part changes are necessary.

Shrinkage

Allow 0.7 to 1.0 % of part dimension for mold shrinkage.

Draw Ratio

EUROPLEX® is capable of a 3 to 1 draw ratio (300 %). Therefore, the height of draw can be three times the width of the part or the ratio of the original sheet thickness to the stretched sheet thickness can be 3/1.

Draft Angles

Use large draft angles of 5° – 7° when part geometry allows. Minimum draft angles should be two to three degrees on a male mold and one half to one degree on a female mold. Molds with textured surfac-es may need more draft so the part will release without scratching. Approximately one degree per mil (25 micron) of texture depth is usually sufficient.

Radii and Fillets

Radii on ribs and fillets should not be less than the minimum part thickness. The radii should be as much as four to ten times the wall thickness in areas of high loading or where extra stiffness is required. Radii should increase as part depth increases.

Undercuts

Generally, undercuts should be avoided. However, if they are necessary, removable inserts or cam-action mold parts should be used.

Vacuum holes

Vacuum holes should be drilled in all areas that require detail. These vacuum evacuation holes should be kept as small as possible to minimize dimple formation on the finished part. Vacuum holes with di-ameters less than 0.750 mm should minimize dimple mark-off. Back drilling with larger holes will produce a more rapid air evacuation and make drilling the small surface holes easier.

Molds can also be made with long slots instead of holes to remove air. Slots are most commonly used in female tooling with a loose bottom insert or for perimeter vacuum on male tools. Slot gaps should be 0.75 mm.

Mold Surface Finish

Since the part detail is better on the side of the material that contacts the mold, female molds are used when exterior part details are required, and male molds should be used when the interior of the part requires detail. Male molds may also be preferred when the exterior surface details are minimal and the exterior polish ore mate finish of the sheet needs to be preserved. Large flat mold surfaces should not be highly polished because they will restrict the flow of vacuum and can cause air entrapment. Slightly sand the mold surfaces in the direction of draw to insure proper vacuum evacuation (600 grit paper is recommended).

Plug Assists

Plug assists pre-stretch the sheet and assist in forming. Plugs are designed to conform to the cavity. Compared to tie cavity, plugs should be 10 to 20 percent smaller in length and width to allow for clearance between the sheet and the mold. Additionally, the plug should have no sharp corners.

Fabrication

The following section discusses the techniques and processes used to fabricate finished products from EUROPLEX® sheets. It also provides recommendations and advice on how to achieve the best results.

Bonding and Fastening

The table below lists several adhesive systems that can be used with EUROPLEX® products. Adhesive thickness is critical to producing acceptable bonds and the adhesive supplier should be consulted for the optimum thickness to use.

Adhesive System	Polycarb	PPSU
PUR	Yes	Yes
Epoxy	Yes	Yes
Hot Melts	Yes	Yes
Methylenchlorid	Yes	No
Cyanurat Instant Adhesive	Yes	Yes

Cutting

EUROPLEX® sheets can be cut with a variety of common hand-held and table mounted sawing equipment. Special attention to blade design and cutting speed is important to obtain good quality finishes. Always take care to protect yourself from injury. Use appropriate eye and ear protection and exercise caution when operating cutting equipment.

Circular Saws

The blade should be designed to minimize blade body rubbing during sawing. Fine tooth hollow ground blades and triple chip carbides are excellent choices and will produce a good quality surface finish.

Thin gauge sheet:
Hollow ground panel blades
4 – 5 teeth per cm

Heavy gauge sheet:
Triple chip cut carbide blades with alternating bevel and straight teeth.
1 tooth per cm

Band Saws

EUROPLEX® sheets can be cut in all thicknesses with band saws.
4 – 6 teeth per cm
Blade speeds 760 – 915 meters per minute

Milling and Routing

High rotating speeds or low feed rates are advisable for end milling. Higher feed rates are permissible, but only with increased milling speeds.

The use of right or left handed spiral cutting bits with handheld or table mounted routers will minimize material chatter and help hold the EUROPLEX® sheet against the router surface.

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Bit Recommendations

- Spiral router bits are preferred
- Two-or thee-fluted carbide tipped bits can also be used

Router Speeds

No-Load speeds: 25,000 – 30,000 rpm

Drilling

EUROPLEX® sheets can be drilled easily using a standard twist drill design. High speed steel or carbide tipped twist drills give the best results.

To minimize the drill's tendency to pull into the material, modify the standard steel twist design by grinding a small flat on the cutting edge.

Shearing, Punching, and Blanking

Punching and shearing are effective methods for cutting EUROPLEX® sheets into workable sizes. However the sheared edge should be removed by a secondary routing operation to minimize high stress areas.

Compared to acrylic, which will shatter, EUROPLEX® sheets will not crack during shearing, punching or blanking when sharp tools are used.

Shearing

Smooth cuts can be obtained by shearing with the following guidelines:

- Shear blades
- Maintain clearance between blade and shear bed

Punching

Hollow ground punches can be successfully used, but it may be necessary to make provision for hole shrinkage if the hole diameter tolerance is critical.

Blanking

The ductility of EUROPLEX® sheets allow for blanking with clean edges, unlike acrylic which is far more brittle.

- Conventional steel rules and clicker dies provide excellent results
- Sharp tools yield the best edges

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