

Eastman SpectarTM Copolyester

Fabricating and Forming Sheet of Spectar Copolyester

D u r a b i l i t y . S u s t a i n a b i l i t y . F l e x i b i l i t y .

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Note: Conversion of metric/U.S. customary values may have been rounded off and therefore may not be exact.

General Health and Safety Precautions Sheet of Eastman Spectar™ Copolyester

Safety

Always exercise good, safe shop practices when fabricating or forming sheet of Spectar™ copolyester and other plastic materials. Heat generated during sawing, machining, finishing, and thermoforming operations can burn unprotected skin. Flying particles and contact with chemicals and vapors are also areas of concern. Be sure to adhere strictly to all instructions in Material Safety Data Sheets (MSDS) provided by equipment and material suppliers. In addition, keep tools sharp and in good working order for safe operation and high-quality work.

Ventilation

It is always good shop practice to work in a well-ventilated area, particularly when solvent bonding or cementing or laser cutting. Provide localized exhaust venting in the work area.

Protective Equipment

Always use appropriate safety equipment (goggles, gloves, hearing protection, etc.) when handling plastic sheet and operating shop equipment.

Storing and Handling Sheet of Eastman Spectar™ Copolyester

Sheet Stock

Heavy-gauge plastic sheet is generally shipped in corrugated cases, on pallets, or as continuous rolls. Store large sheet flat with masking intact. Sheet stored on edge in storage racks should have a supported, slightly angled backboard (A-frame) to prevent sheet from warping. Be sure storage areas are clean, dry, cool, and well ventilated. When possible, rotate inventories on a first-in/first-out (FIFO) basis.

Masking

Sheet of Spectar™ copolyester is protected with a mask of polyethylene film. Whenever possible, leave the masking intact during fabrication. Use older stock first. Also, avoid any unsupported overhang of the sheet during storage.

Remove any masking adhesive residue on the sheet with a clean, soft cloth dampened with a 50:50 mixture of isopropyl alcohol and water. If the sheet has a static charge after removing the masking, wipe the sheet with a clean cloth slightly dampened with water to help remove the charge.

Handling Formed Parts

Formed parts will continue to cool after they are removed from the mold. To prevent deformation, it is important to provide proper support during cooling. Also, avoid any unsupported overhang of the flat sheet or formed parts. To prevent dishing (becoming concave), support parts along their edges, facedown, until completely cooled. Do not nest-stack formed parts.

General Health and Safety

- Wear gloves when handling large sheets to prevent cuts.
- Keep masking in place for as long as possible.
- Keep tabletops clean to avoid scratching the sheet.
- Store sheets flat, as delivered, to prevent warpage. If vertical storage is necessary, it is best to store the sheet and formed parts at a slight angle with full support underneath.
- Support large, formed panels by their edges, facedown, while cooling.
- Store material indoors in a dry, cool, well-ventilated area.
- Use the FIFO method to rotate inventory.
- Do not use a knife or scraper to remove masking.
- Do not store plastic sheet near radiators, steam pipes, or in direct sunlight.

Cleaning Sheet of Eastman Spectar™ Copolyester

Dust and Dirt

Remove dust and dirt from sheet of Spectar™ copolyester with a soft cotton cloth and a solution of mild soap or liquid detergent in water. A 50:50 solution of isopropyl alcohol and water also works well. Remove grease and residue from tape or paper masking with naphtha followed by a water wash. Always use a soft, damp cloth and blot dry. Rubbing with a dry cloth can scratch the material and create a static charge. Never use scrapers or squeegees on sheet of Spectar™ copolyester. See additional cleaning instructions on page 26.



Do not: Use a squeegee.
Use strong solvents.
Rub with a dry cloth.

Sawing, Routing, and Laser Cutting Sheet of Eastman Spectar™ Copolyester

General Recommendations

If possible, leave the original masking on the sheet during cutting operations. In addition, cover working surfaces with a soft, clean cloth to prevent scratching.

Use sharp, clean blades, holding the sheet securely in place. Bring the blade to full speed before starting the cut and use compressed air to cool the blade and remove chips.

Wear proper safety equipment including safety glasses, gloves, and protective clothing as required by local regulations.

Saw and Cutter Types

Most saws commonly used for wood or metal should satisfactorily cut sheet of Spectar™ copolyester. These include circular saws, band saws, saber saws, jigsaws, hacksaws, or handsaws. However, circular saws and band saws usually produce smoother, cleaner, faster cuts. Routing is also a common technique.

For the highest quality cut, use a triple-chip style carbide-tipped blade commonly used for plastics. Several sheets of Spectar™ copolyester can be stacked and cut together but only if the stack is held securely to prevent movement from sheet to sheet. Otherwise, chipping and irregular cuts may result. Use a slow and consistent feed rate.

Blade Characteristics

Circular Saws

- Number of teeth—2 to 4 teeth per 25 mm (per in.).
- Blade thickness— 2.5 mm ($\frac{3}{32}$ in.) for single sheets in thicknesses of 1 to 10 mm (0.040 to 0.375 in.); 3 mm ($\frac{1}{8}$ in.) blade should be used for cutting thicker sheet.
- Blade tooth rake angle—0–5°.
- Depth of cut—for best results, allow the blade to protrude through the piece by no more than 3 mm ($\frac{1}{8}$ in.). This will minimize the chance of creating a chipped edge.
- For circular saws, the following blade speeds are recommended:

Blade Diameter, mm (in.)	Blade Speed, rpm
100 (3.5–4) Trimming Saw use Wood Combination Blade	10,000
180 ($7\frac{1}{4}$)	5,000
200 (8)	4,300
250 (10)	3,400
300 (12)	2,900
350 (14)	2,500

Band Saws

- Number of teeth—8 to 14 teeth per 25 mm (per in.) for general cutting; 18 to 24 per 25 mm (per in.) for a smoother, cleaner edge.
- Blade width—for intricate cuts and tighter turns, 6 to 10 mm ($\frac{1}{4}$ to $\frac{3}{8}$ in.) is suggested. For straight cuts, larger turns, 12 to 25 mm ($\frac{1}{2}$ to 1 in.) is suggested.
- Blade speed—approximately 760 mm (2,500 ft) per minute.

Saber Saws and Jigsaws

Always hold your work securely in place. This is especially important when using a saber saw or jigsaw. Excessive vibration can cause cracking and/or possible injury.

- A blade with 6 to 10 teeth per 25 mm (per in.) works well with the orbital action setting at zero.
- A scroll-type blade with 12 to 20 teeth per 25 mm (per in.) can be used to achieve a good edge finish on intricate cuts.

Handsaws and Hacksaws

Although not commonly used on sheet of Eastman Spectar™ copolyester, handsaws and hacksaws can work satisfactorily if used carefully and with little pressure. Use sharp blades that range from 6 to 18 teeth per 25 mm (per in.), depending on the desired finish. As always, securely support the sheet to avoid flexing.

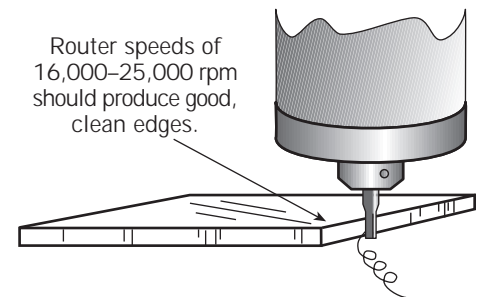
Routers

Routing with sharp, two-flute, carbide tipped straight cutters produces very smooth edges. Twisted two-fluted cutters work exceptionally well. Also spiral-cut router bits have been found to work successfully, depending on the application. It is especially useful for trimming the edges of flat or formed parts, or parts too large or irregular in shape to cut with a band saw. Portable, overarm, and small table routers work equally well.

- Use router speeds of 16,000 to 25,000 rpm to produce good, clean edges.
- Feed the sheet into the router slowly to avoid excessive frictional heating, shattering, or

chipping.

- Use a suitable jig to support the sheet during routing.
- Use compressed air to cool the bit and to aid



in chip removal.

Laser Cutting

Spectar™ copolyester can be laser cut using the same equipment as that used for cutting acrylic. Typically lower power settings and slower cutting rates are required when cutting sheet of Spectar resin vs. acrylic sheet. It is also recommended that a cutting table with good vacuum ventilation be utilized to remove the byproducts created during the cutting process. This applies for both sheet of Spectar™ copolyester and acrylic sheet.

Eastman is currently working with laser equipment to better understand the laser cutting system when working with sheet of Spectar™ copolyester. Please contact Eastman Technical Service for further updates.

Tips for Cutting Sheet of Eastman Spectar™ Copolyester

Eastman Chemical Company's recommendations are based on experience working with sheet of Spectar™ copolyester. They can be used as a starting point or as guidelines for cutting these products.

- Use tools designed for plastic.
- Use sharp blades: Jigsaws should be equipped with a scroll-type blade for detail work and a coarse-toothed blade for better chip removal on heavier work. For circular saws, a carbide-tipped, triple chip tooth pattern is recommended.
- Hold sheet firmly while cutting to minimize vibration, especially for thinner gauges (<120 mil).
- Keep feed rate slow and constant when cutting.
- Do not reverse the natural curve of the material when cutting sheet from roll stock. This overstresses the sheet and can cause fractures.

Operation	Type of Equipment	Recommendations
Trimming	Router Bits	¼ inch minimum, 2 edged is recommended, 3–4 fluted for larger bits (i.e., Onsrud #52-624), these are twisted flutes
	Router Blades	4-Wing carbide tip, slotting cutter (i.e., Whiteside Part #6700B), >20K rpm, slow/med cut speed
	Jigsaw	Recommend 10 teeth/inch for smoothest cut
	Band Saw	Recommend minimum of 6 teeth/inch
	Circular Saw (3.5–4" diameter)	Carbide, triple chip tooth cut recommended if can find, otherwise use a wood combination blade (i.e., Makita), 2 mm rake, >10K rpm
	Circular Saw, 7" diameter	60-tooth carbide-tipped blade, triple chip tooth cut if possible
	Roto-zip Type	ZB10 bit for small trim (<=0.150" sheet), Onsrud #52-624 for (>=0.150" sheet)
	Kett Saw	Blade #157-66, 2.5", 80 teeth, rate of cut will determine quality of cut, keep sharp blade to prevent melting of plastic
Drilling	Drill Bits	Those normally recommended for plastics

Troubleshooting Guide for Cutting Sheet of Eastman Spectar™ Copolyester

Problem	Possible Cause	Possible Solution
Rough or chipped edges	High feed rate Sheet vibration Blade protrusion Broken teeth Blade too coarse	Reduce feed rate. Secure sheet firmly. Limit to maximum of 3 mm (1/8 in.). Replace blade. Use more teeth/in. (mm).
Cracking	Blade and fence not parallel Sheet vibration Feed rate too high	Realign blade and fence. Secure sheet firmly. Reduce feed rate.
Surface scratching	No masking Dirty work surface Jigs/fixtures are nicked, burred	If possible, leave masking intact. Clean work surface. File, sand, or polish to remove burrs.
Blade gums up	Dull blade Inconsistent feed rate Feed rate too slow Improper blade	Sharpen or replace blade. Use steady, even feed rate. Increase feed rate. Use blade specified.
Dust buildup	Dull blade Clogged blade Static charge on sheet Masking removed	Sharpen or replace blade. Clean or replace blade. Wipe with damp cloth. Leave masking in place.

Drilling Sheet of Eastman Spectar™ Copolyester

Drills and Bits

Sheet of Spectar™ copolyester can be readily drilled, using a standard drill press or handheld drill with sharp, clean drill bits. Drill bits designed for use with plastic are recommended. Bits designed for use with polycarbonate have been found to work well with sheet of Spectar™ copolyester. Standard drill bits can, on occasion, be used but may have to be ground to reduce the depth or angle of cut. As with any plastic sheet product, it is important to keep vibration to a minimum to prevent chipping or cracking. Hold the work securely in place when drilling but avoid excessive clamping pressure.

Drilling Procedure

Optimum bit speed, feed rate, and applied pressure will depend on hole size and sheet thickness. Drill speeds up to 1,750 rpm are best for smaller holes, while speeds as low as 350 rpm can work for larger holes. Use water or compressed air to minimize heat buildup when

drilling sheets thicker than 4.8 mm (0.187 in.), stacked sheets, or very large holes.

When drilling holes that will penetrate the second surface, back up the piece with wood to cushion the drill bit as it passes through the sheet. Move the drill bit in and out to remove plastic shards.

Avoid topping a drilled hole or using self-topping screws.

Summary

- Use sharp drill bits designed for plastic.
- Use just enough clamping pressure to prevent vibration.
- Use a load spreader to distribute clamp pressure evenly.
- Use compressed air to prevent overheating, especially if sheet is more than 4.8 mm (0.187 in.) thick.

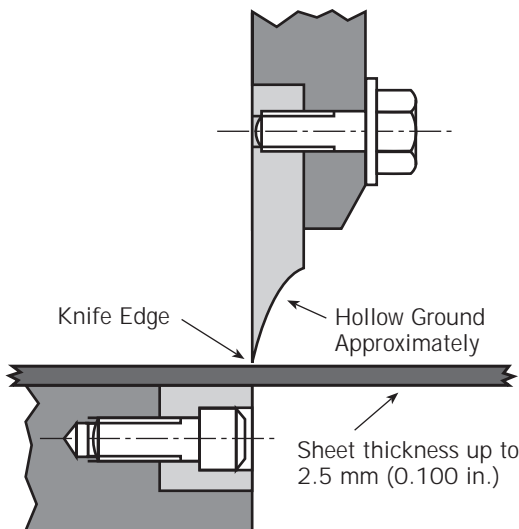
Shearing, Punching, and Die-Cutting Sheet of Eastman Spectar™ Copolyester

General Recommendations

Sheet of Spectar™ copolyester is a tough but ductile material and can be sheared, punched, and die-cut when proper tools and techniques are used. A shear cut yields a straight edge, while punches and dies can be used to produce holes of almost any desired shape.

Shearing

A power shear can be used to cut sheet in thicknesses up to 2.5 mm (0.100 in.). For thicker sheet, sawing is recommended. To achieve smooth cuts, maintain a blade-to-bed knife clearance of approximately 0.025 mm (0.001 in.). The following diagram shows a typical shearing assembly.



Shear Strength

The following table shows shear strength requirements for cutting various thicknesses of sheet of Spectar™ copolyester.

Shear Strength Requirements (ASTM D732, Shear Strength Determination Method)

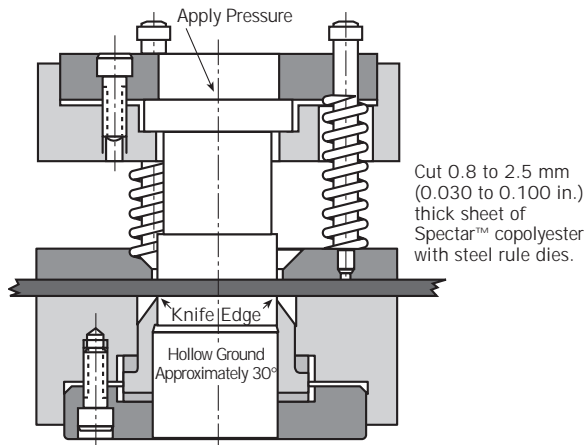
Thickness, mm (in.)	Sheet Shear Strength, MPa (psi)
2 (0.080)	57.6 (8,354)
3 (0.118)	56.5 (8,195)

Punching

When a particularly sharp or smooth cut is not required, a punch can be used. Hand-operated punches are useful for small holes, but larger holes may require a power-operated punch. Heating the sheet to approximately 38°C (100°F) will minimize the possibility of cracking or chipping; however, allow for hole shrinkage due to cooling. We recommend sawing, drilling, and routing instead of punching sheet thicker than 2.5 mm (0.100 in.).

Die-Cutting

Cut 0.8 to 2.5 mm (0.030 to 0.100 in.) thick sheet of Eastman Spectar™ copolyester with steel rule dies. These are usually 12.5 mm (½ in.) deep and are mounted in a properly shaped slot cut into a wooden block (see the following diagram). While relatively inexpensive, steel rule dies must be sharpened or replaced fairly often to remain effective.



Die Press Capacity

A die press must have adequate power to achieve the desired cut. Use the shear strengths shown on page 11 with the following formula to calculate the required press capacity.

$$F = \frac{S \times P \times T}{C}$$

where:

- F = Required press capacity in tons
- S = Sheet shear strength in MPa (psi)
- P = Perimeter of cut in mm (inches)
- T = Thickness of sheet in mm (inches)
- C = 8,896 N/ton (2,000 lb/ton)

Example:

A 3 mm (0.118 in.) thick sheet of Spectar™ copolyester requires a shear strength of 56.5 MPa (8,195 psi). The press tonnage required to die-cut a sheet measuring 381 mm (15 in.) square is calculated in the following equation. The perimeter measurement is calculated by multiplying 0.381 m (15 in.) × 4 because the shape is square.

SI Units

$$F = \frac{(56.5 \text{ MPa}) (3 \text{ mm}) (1,524 \text{ mm})}{8,896 \text{ N/ton}} = 29 \text{ ton}$$

U.S. Customary Units

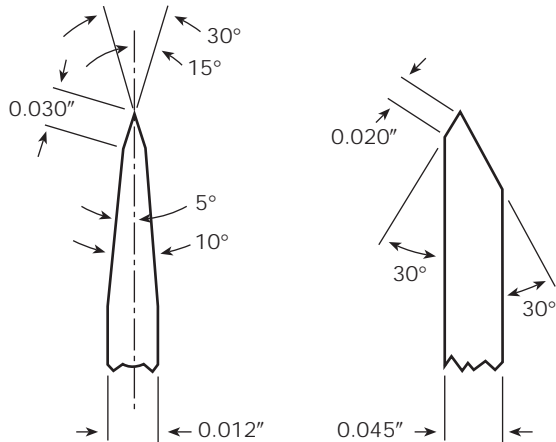
$$F = \frac{(8,195 \text{ psi}) (60 \text{ in.}) (0.118 \text{ in.})}{2,000 \text{ lb/ton}} = 29 \text{ ton}$$

NOTE: The actual cutting force required to cut through a thicker sheet increases with added sheet thickness. Shear strength (psi) is calculated by dividing the cutting force by the sheared area.

However, as sheet thickness increases, the sheared area (sheet thickness × cut length/perimeter) over which the cutting force is distributed increases at a greater rate than the magnitude of the required cutting force, thus causing the shear strength values to decrease with increasing thickness.

Die Design

Designs for 2 steel-rule cutting edges that work equally well with sheets up to 2.5 mm (0.100 in.) thick are shown below. Steel hardness should be 45 to 55 Rockwell C, depending on the degree of bending required in fabrication.



Die-Cutting Procedure

Adjust the press to make a complete cut in a single stroke without damaging the die. Shim the die as necessary to ensure that all areas cut uniformly through the sheet of Spectar™ copolyester. To ensure that the entire die is level and true:

- Tape Kraft or carbon paper, 150 to 200 mm (0.006 to 0.008 in.) thick, to the plate.
- Lower die to mark an imprint of the cutting pattern.
- Shim low rule areas.
- Make a test cut.
- Alternate cutting/shimming until a full, uniform cut is obtained.
- Position test parts consistently.
- Keep cutting dies as sharp as possible.

To prevent contact between the die and the press bed, use a steel cutting plate 0.5 to 3 mm (0.020 to 0.118 in.) thick with a Rockwell C hardness of 30 to 35.

Bonding, Fastening, and Welding Sheet of Eastman Spectar™ Copolyester

Bonding Methods

Solvent bonding is generally preferred when the components to be joined are made from sheet of Spectar™ copolyester. However, when joining dissimilar materials or considerations such as part size, bond flexibility, or bond appearance prevail, adhesives, mechanical fastening, or plastic welding may be needed. Recommended adhesives include cyanoacrylates, two-part acrylics, two-part polyurethanes, and two-part epoxies.

Solvent Bonding

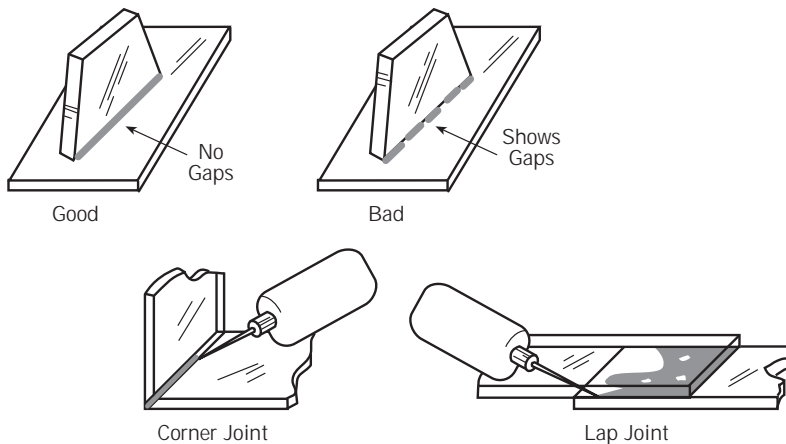
The excellent chemical resistance of sheet of Spectar™ copolyester allows its use in certain applications where other plastic materials might be unsuitable. This feature must be taken into account when choosing a solvent for an optimum bond. Use of a proper solvent, good technique, and cure time should result in a clear, haze-free joint that is strong and durable. Whether using the capillary action technique commonly employed for smaller parts and bonds of fairly short length or some other method, the parts

must fit together well without forcing—**leaving no visible gaps**. For the best bonding results, allow the solvent to fully penetrate the edges to be bonded.

Solvent Selection

There are several options for bonding sheet of Spectar™ copolyester to itself. These include commercial products as well as custom blends of MEK and methylene chloride. You may also consult the sheet extruder or your distributor for additional solvent agents suitable for use with sheet of Spectar™ copolyester.

MEK, a fast-acting solvent, gives quicker setup with more likelihood of freeze-off (setting up before the joint is filled). Methylene chloride, on the other hand, is a slower solvent and offers more work time with less potential for freeze-off. In some locations, a 50:50 mix of methylene chloride and MEK is used as a starting point to formulate custom solvent blends. A small amount of acetic acid can be added when bonding in humid environments.



- Use needle-type applicator.
- Apply solvent evenly along entire length.
- Apply from inside for corner joints.
- Apply from both sides for lap joints.

Some water-thin formulas designed for bonding acrylics can also be used to bond sheet of Eastman Spectar™ copolyester to itself if they are used with care. Weld-On® 3 and Weld-On® 4, available from IPS Corporation, are two such formulas. Hazing may, however, occasionally be observed.

Do not use thick cements intended for use with other plastics; they are generally incompatible with sheet of Spectar™ copolyester.

Troubleshooting Guide for Solvent Bonding

Problem	Possible Cause	Possible Solution
Solvent freeze-off	Use of improper solvent Solvent too active Application technique	Switch to a system designed for sheet of Spectar™ copolyester. Dilute mixture with a slower solvent. Reevaluate technique.
Hazy/cloudy joints	Use of too much solvent Poor part fit Solvent pooling Old solvent mixture	Use less solvent. Improve part fit. Check leveling of part to reduce pooling. Add fresh solvent.
Weak joints	Use of improper solvent Application technique Poor part preparation	Switch to a system designed for sheet of Spectar™ copolyester. Reevaluate technique. Prepare part properly.
Voids appear as part cures	Use of too much solvent Poor part fit Solvent pooling Part shifts during setup Overly rough surface	Use less solvent. Reshape parts to improve fit. Check leveling of parts as solvent is applied. Increase clamping pressure and/or use a jig to hold the parts in place while the bond sets up. Lightly sand surface.

Adhesive-Bonding

When joining dissimilar materials, solvent bonds are rarely strong and durable, so the use of adhesives is often recommended for this purpose. The adhesive selected must be compatible with each material involved.

If the materials being joined expand and contract at different rates, a flexible bond may be required. Take this into account when selecting the adhesive formulation. If expansion and contraction are a major concern, consider the use of mechanical fastening.

Adhesive Characteristics

A variety of adhesives are available for joining dissimilar plastic materials. As a result, it is difficult to make general observations. Unlike solvents, which evaporate, an adhesive layer remains a functional part of the finished assembly. Hence, the performance and appearance of the finished part may depend primarily on the characteristics of the adhesive layer.

For example, the selection of a brittle adhesive, or one that contains aggressive chemicals, may lower the impact strength of sheet of Eastman Spectar™ copolyester. Several characteristics to consider when selecting an adhesive are:

- Chemical compatibility with the parts being joined
- Aesthetics of the finished joint
- Expansion/contraction with temperature changes
- Brittleness/rigidity/flexibility
- Weatherability, if required
- Durability/service life
- Adhesive strength (adhesion to the plastic)

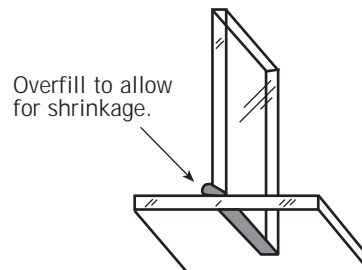
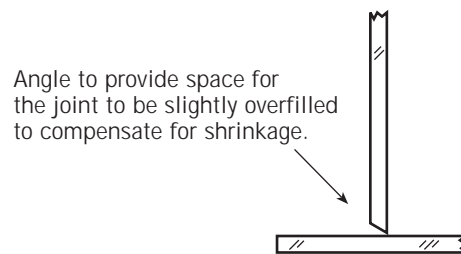
- Cohesive strength (resistance to internal tearing)
- End-use requirements
- Suitability for food contact

Adhesive-Bonding Procedure

Joined surfaces must fit well without forcing and have no visible gaps. The surfaces to be bonded should be smooth but not polished. Sand the surfaces to be joined with a 120 grit or finer paper. Diamond-wheel polishers, jointer/planers, or other mechanical devices can produce excellent results. However, soft-polishing wheels or flame polishing are not recommended as these can round the edges, causing gaps and improper fit.

Adhesive Shrinkage

Some adhesives with a volatile component may shrink while curing. To compensate for this, cut the joint on an angle, providing space for the joint to be slightly overfilled to compensate for shrinkage. Consult your adhesive suppliers' literature for specific information on shrinkage.



Tips on Adhesive Bonding

- Use an adhesive system to bond sheet of Eastman Spectar™ copolyester to other materials such as acrylic or polycarbonate:
 - For bonding sheet made with Spectar™ copolyester to itself, use Weld-On® 58, Weld-On® 55, Weld-On® 42, Scotch-Weld® DP-100, Durabond® 105CL, Light Cure® 3104, Light Cure® 3105, Ultra Light-Weld® 3072, or Plastic Welder® II.¹
 - For bonding sheet of Spectar™ copolyester to sheet of acrylic, use Weld-On® 42, Durabond® 105CL, Light Cure® 3104, Light Cure® 3105, Ultra Light-Weld® 3094, Ultra Light-Weld® 3072, or Plastic Welder® II.¹
 - For bonding sheet of Spectar™ copolyester to sheet of polycarbonate, use Weld-On® 58, Weld-On® 55, Durabond® 105CL, Light Cure® 3104, Light Cure® 3105, Ultra Light-Weld® 3094, Ultra Light-Weld® 3072, or Plastic Welder® II.¹
- Use the following procedure:
 - Start with a flat surface.
 - Prepare the sheet properly:
 - Remove all foreign particles.
 - Wipe surface with a 50:50 mixture of isopropyl alcohol and water.
 - Allow surfaces to dry thoroughly before bonding.
 - Sanding with fine-grit sandpaper to lightly roughen the surfaces to be bonded may improve bond strength.
 - Apply the two-component system to one surface.

- Place the two surfaces in desired bonded position.
- Fill joints completely with adhesive so that no voids remain.
- Use a jig or fixture to securely hold parts being bonded together while curing.
- Follow manufacturer's recommendations for proper pressure and time needed for the adhesive to cure.
- Always use proper ventilation.

Mechanical Fastening

Because of its outstanding toughness, sheet of Spectar™ copolyester adapts to mechanical fastening more readily than some other materials. This method is useful when assembling or installing large or heavy parts, or when a suitable solvent or adhesive system is not available.

Use screws designed specifically for plastics. If bolting parts together, allow for thermal expansion and contraction by drilling oversized holes. Make sure the holes have smooth edges. Use of washers is suggested when bolting for better load distribution.

Use metal inserts if frequent assembly/reassembly is involved. Inserts are not recommended where thermal expansion and contraction may occur.

Do not overly tighten screws or use self-tapping screws.

¹Weld-On® is a trademark of IPS Corporation; Scotch-Weld® is a trademark of 3M; Durabond® and Light Cure® are trademarks of Loctite; Ultra Light-Weld® is a trademark of Dymax; and Plastic Welder® is a trademark of Devcon.

Plastic Welding

Always predrill the opening for the rivet large enough to allow for expansion and contraction of the plastic sheet. The use of metal rivets are not recommended when mechanically fastening any plastic sheet, but if it is necessary to use metal rivets to fasten Eastman Spectar™ copolyester, use rivets that are specifically designed for plastics. They should have large fastening heads to distribute the stress load on the “rivet head” side. Also, the use of a washer on the “non-rivet head” side of the rivet is required to distribute the stress load that will be induced when using tightening metal rivets. When using plastic rivets, also allow for expansion and contraction of the sheet. Plastic rivets are recommended.

Technology has been developed that allows plastic sheet fabricators to obtain clear, strong bonds by welding with a rod of sheet of Spectar™ copolyester material. The technology can be used to bond sheet of Spectar™ copolyester to itself or to other plastic sheet materials.

Like metal welding, particularly wire-feed welding, plastic extrusion welding produces a strong, uniform bond on plastic sheet or other plastic applications.

There are many advantages of plastic welding that can be easily realized when working with sheet of Spectar™ copolyester. Advantages include:

- No messy or environmentally unsafe glues or solvents.
- Clear, yet tough bonds.

- Quick fabrication—no drying time required.
- Water tight, long-lasting joints.
- Diverse fastening method for a variety of applications.
- Better, stronger designs.
- Suppliers of copolyester rods:
 - K-Mac Plastics
3821 Clay Avenue, SW
Grand Rapids, MI 49848
(616) 406-0671
www.k-mac-plastics.com
 - New Image Plastics
2411 S. Locust Street
Canal Fulton, OH 44614
(330) 854-3010
www.plasticweldingrod.com

Tips for Bonding Sheet of Eastman Spectar™ Copolyester

The bonding recommendations outlined here are based on experience working with Spectar™ copolyester in Eastman Chemical Company's Technical Service Laboratories in Kingsport, Tennessee. They can be used as a starting point or as guidelines in determining optimum bonding conditions.

- Start with a clean, flat surface.
- Prepare the sheet properly.
all foreign particles.
 - Wipe surface with a 50:50 mixture of isopropyl alcohol and water.
 - Allow to dry thoroughly before bonding.

- Use an appropriate solvent or adhesive for:

Bonding Sheet of Spectar™ Copolyester to Itself

- Use solvents such as methylene chloride, cyclohexanone, tetrahydrofuran, Weld-On® 3, Weld-On® 4, Caseway SC125, MC-Bond, or a two-component adhesive such as Weld-On® 58.¹

Using Solvents

- Be sure that surfaces to be bonded are smooth and mate well. Edge bonds should be finished using a jointer or router.
- Apply the solvent to the edge of the joint with a hollow needle. Solvent will wick into the joint by capillary action.
- Use the minimum amount of solvent to wet the surfaces to be bonded.

- Use a jig to hold parts in place prior to bonding.
- Greentime is typically 60–90 sec.

Using a Two-Component Adhesive System

- Apply the two-component system to one surface.
- Use light pressure to hold the surfaces being bonded together.
- Follow manufacturers' instructions for details.

Bonding Sheet of Spectar™ Copolyester to Other Materials Such as Acrylic or Polycarbonate

- Use an adhesive system rather than a solvent-based system.
- Use Weld-On® 58 or Weld-On® 42.¹
- When using adhesives, sanding with fine-grit sandpaper to lightly roughen the surfaces to be bonded may improve bond strength.
- Apply the two-component system to one surface.
- Follow manufacturers' recommendations for the proper pressure and time needed for the adhesive to cure.
- Eastman has found that urethane-based adhesives work best.
- Do not use too much solvent or allow solvent to pool on the plastic.
- Do not use methyl ethyl ketone, cyclohexanone, or THF for edge bonds.

¹Weld-On® is a trademark of IPS Corporation.

Troubleshooting Guide for Bonding Sheet of Eastman Spectar™ Copolyester

Problem	Possible Cause	Possible Remedies
Poor Bond Appearance	Voids due to rough surfaces	Need smoother edges. Start with jointed edges. Add router edge.
	Whitening due to solvent induced crystallization	Minimize amount of solvent used (avoid solvent pooling). Try using "dip" method. Switch to adhesives.
	Whitening/bubbles due to high humidity	Fabricate in an area with low relative humidity. Use solvents with a slower evaporation rate.
	Parts moved before bond sets	Use a jig, clamp, or fixture to hold the parts fixed until the bond has set up.
Solvent Bond Strength	Wrong solvents	Use recommended solvent.
	Excessive surface roughness	Start with a jointed/routed edge. If necessary, add methylene chloride to the solvent mixture to help dissolve the roughness.

For additional information on the adhesives and solvents discussed, contact:

AAM Manufacturing Inc.
1755 Hubbard Drive
Batavia, IL 60510
Tel: (630) 406-9600
Fax: (630) 406-9622

IPS Corporation
17109 South Main Street
Gardena, CA 90248
Tel: (800) 523-2575
(310) 366-3300
Fax: (310) 515-6461

Poly Sciences, Inc.
400 Valley Road
Warrington, PA 18976
Tel: (800) 523-2575

Forming Sheet of Eastman Spectar™ Copolyester

Forming Methods

Sheet of Spectar™ copolyester is uniquely suited to a variety of forming operations, offering a combination of features unmatched by acrylic or polycarbonate. The sheet can be formed without predrying, forms at lower temperatures, heats and cools rapidly, releases easily from the mold, and processes with impressive consistency, all which translate into major labor, energy, and capital savings. Deep draws and intricate part definition are routine, using simple vacuum pressure. The most common thermoforming techniques include line-bending, free-forming, and vacuum-forming.

Thermoforming Oven

Sheet of Spectar™ copolyester may be heated using single- or double-sided radiant heat or convection ovens. While single-side heating is common, it can heat the sheet unevenly. However, sheet of Spectar™ copolyester will form well using one-sided heat at gauges $\leq 0.177''$. For more critical applications such as distortion screen-printing, complex shapes, or very deep draws, use double-sided radiant heat with zone control if possible.

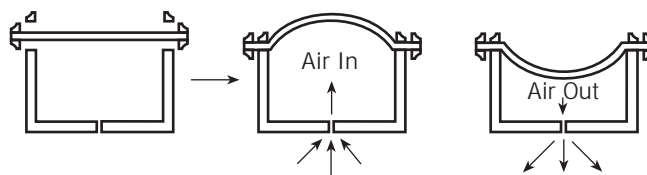
Vacuum-Forming

Line-bending and free-forming limit the variety of shapes that can be produced from sheet of

Spectar™ copolyester. There is, however, virtually no limit to the variety of shapes that can be achieved through vacuum-forming. In this process, heat the sheet and then position over a male or female mold. Evacuate the air between the sheet and the mold surface. Hold the vacuum while the part cools, then release the vacuum and remove the part from the mold. Positive pressure, or a combination of positive and negative pressure, can be used. Sheet of Spectar™ copolyester can be thermoformed on virtually any horizontal thermoforming equipment.

Free-Forming

Free-forming is a good technique to produce domes, bubbles, and other symmetrical shapes. Achieving some shapes may be as simple as allowing the sheet to sag in the oven, without pressure, to a desired depth, at which point the part is removed to cool. Heat the sheet, then seal against the opening of a pressure box and apply air pressure to force the sheet into the desired shape. Hold pressure constant while the part cools. The shape of the opening and the quantity of air forced into the box determine the shape. In either case, the formed part exhibits an excellent finish because the heated sheet never makes contact with a mold surface. Another option involves using a vacuum box that gives similar results.



Hold pressure constant while the part cools.

Line-Bending

To line bend, heat the sheet on one side to 100°C to 120°C (212°F to 250°F) along a straight line. Bend to the desired angle and hold in place until the part has cooled and the new shape is set. A jig is useful for holding the part in place during cooling, although it may be possible to hold the part in the desired position by hand.

Cold-Bending

Cold-bending can be used to produce simple shapes from sheet of Eastman Spectar™ copolyester. When brake-forming, the maximum amount of bend will depend on sheet thickness and rate of deflection. Cold-bending sheet more than 2.5 mm (0.100 in.) thick will likely cause high stress levels, which may lead to part failure. When cold-bending, use the general recommendation of radius equals 100 × thickness of sheet.

Forming Temperature

Sheet of Spectar™ copolyester will form at lower temperatures and over a wider range of temperatures than acrylic or polycarbonate. Typical oven temperatures of 200°C to 260°C (400°F to 500°F) produce corresponding sheet temperatures of 135°C to 155°C (275°F to 310°F), measured from the top of the sheet (in top heat only oven). Too much heat can result in

excessive sag, which may lead to webbing or bridging when a vacuum is applied. Monitor sheet temperatures with an infrared thermometer or observe the degree of sag. If the sheet has been stored for long periods under conditions of high humidity, select a forming temperature on the lower end of the range.

A general guide to forming temperature follows:

Factor	Temperature Range
Deep draws	Higher end
Moderate draws	Lower end
Large parts	Lower end
High moisture	Lower end
Complex detail	Higher end

Part Removal

Reduce the possibility of warping by allowing formed parts to cool to 50°C (120°F) or lower before removing them from the mold. They will continue to cool after removal, so proper support is required to prevent deformation. This is especially true for large, heavy parts. To prevent dishing (concave shape), large parts should be supported along their edges, facedown, until completely cooled. Do not nest formed parts since this can cause blocking and scratching. Large parts should be fully supported when being transported to prevent excessive flexing.

Molds

Mold Materials

Commonly used mold materials include wood, vacuum board (medium density fiber board), pressure laminates (for flat surfaces), plasters, aluminum-filled epoxies, automobile body putties, fiberglass, and aluminum. Molds made from wood or vacuum board are inexpensive and easy to fabricate into the desired shape with common woodworking tools. Limitations of wooden molds include durability, slower part cooling, and less control over surface texture.

Mold Finish

Formed sheet of Eastman Spectar™ copolyester provides an excellent reproduction of the mold surface. For this reason, vacuum holes should be no more than 0.4 mm (0.015 in.) in diameter. Keep the mold surface clean during the forming operation (even dust marks can be picked up in the surface of the formed part). A smooth, clean mold surface produces a smooth, clean formed part. On the other hand, using unique mold finishes offers a wide range of customized design possibilities.

Mold Design

Formed sheet of Spectar™ copolyester typically has very good release characteristics. For most male molds, a minimum draft angle of 5 to 7 degrees ensures easy part removal. Large-scale production runs may justify the production of a prototype mold to determine optimum draft angles, shrinkage, and other mold design features. Parts formed from sheet of Spectar™ copolyester will typically shrink about 0.5%.

Sharp edges and corners on molds should be avoided. A minimum internal corner radius equal to the initial sheet thickness is required. Although formed sheet of Spectar™ copolyester typically has very good release characteristics, the complexity of the mold has a significant effect.

Thickness Control

The wall thickness of vacuum-formed parts varies with thinner areas occurring at the points of deepest draw or greatest stretch. For example, if a pan configuration is drawn into a female mold, the thinner areas will occur at the corners, or face, of the formed part. Material distribution can be optimized through mold design, the use of plug assist, or billowing, depending on the specific design of the part.

Predecorated Sheet

Since it forms at lower temperatures, sheet of Spectar™ copolyester may be used with less concern about overheating preapplied inks or vinyl films. In some cases, parts have been formed with the decorated surface in contact with the mold with no adverse effects. The compatibility of sheet of Spectar™ copolyester with vinyl can allow thicker gauge sheet to be used than with polycarbonate without the fear of damaging the vinyl. These factors make predecoration and subsequent forming a snap! Another factor in predecorating the sheet of Spectar™ copolyester is its even material distribution during the forming process, leaving less chance for ink, paint, or vinyl thinning.

Troubleshooting Guide for Thermoforming Sheet of Eastman Spectar™ Copolyester

Problem	Possible Cause	Possible Solution
Webbing or bridging	Sheet too hot Complex shape	Decrease heating time or temperature. Use female mold and/or prestretch sheet with plug or pressure assist.
Bubbles in formed sheet	Sheet too hot	Reduce forming temperature.
Surface defects on part	Oversized vacuum holes Rough mold surface Dirty mold	Use smaller holes. Sand/polish mold. Use aluminum mold. Clean mold.
Release difficulties	Insufficient draft	Increase draft angle or use female mold.
Poor material distribution	Forming technique Uneven heat	Try plug, bubble, or vacuum assist. Adjust heat zones.
Uneven sag	Uneven heat	Adjust heat zones.
Poor detail	Vacuum released too soon Vacuum applied too slowly Sheet too cold	Hold vacuum longer. Apply vacuum sooner. Increase heating time or temperature.
Warped parts	Insufficient cooling	Allow parts to cool longer in mold.

Tips on Thermoforming Sheet of Eastman Spectar™ Copolyester

Eastman Chemical Company's thermoforming recommendations are based on experience working with sheet of Spectar™ copolyester in its Technical Service Laboratories in Kingsport, Tennessee. They can be used as a starting point or as guidelines in determining optimum sheet thermoforming conditions.

- Use a minimum draft angle of 5° in male molds for easy part release.
- Keep molds very clean. Remove dust with a damp cloth and blow it off with pressurized air.
- Use lower oven temperatures [200°C–250°C (400°F–480°F)] than used for acrylic and polycarbonate.
- Use a lower mold temperature than used for acrylic or polycarbonate. For long-term production, a temperature-controlled mold is recommended but not required.
- Heat the sheet to 135°C–155°C (275°F–310°F). The optimum is 150°C (300°F) using a top heater oven and measured from top of sheet. Apply heat on the side that will be outside the bend.
 - Higher temperatures for deep-drawn parts and high detail.
 - Lower temperatures for large parts and shallow draws.
- Use amount of sag as a sheet-heating control.
- Use a vacuum of 508 mm (20 in.) Hg or greater.
- Remove the part at lower temperatures [50°C (<120°F)] to prevent part warpage. When using a male mold, the part should be removed as soon as possible and then placed back onto the mold. This helps prevent the part from sticking to the mold and helps prevent part warpage as it continues to cool.
- For highly detailed molds, a light dusting with talcum powder helps the part to release more easily and will extend the life of the mold as well.
- Always allow generous radii on internal corners (\geq initial sheet thickness).
- Do not dry the sheet before thermoforming—not necessary.
- Do not use too cold a mold [25°C (<60°F)] to prevent nonuniform stretching and part warpage.
- Do not use too hot a mold [60°C (>122°F)] to prevent warping or sticking.
- Do not overheat the sheet [165°C (>330°F)] to prevent excessive sagging.

Decorating Sheet of Eastman Spectar™ Copolyester

There are literally hundreds of commercially available inks and paints that can be used to decorate sheet extruded from Spectar™ copolyester. When choosing ink or paint, consideration should be given to the fitness-for-use requirements of decorated parts. For example, will the decorated part be subjected to consumer abuse or will it encounter little or no abuse, such as a decorated sign. The following information offers some general guidance regarding the decoration of sheet of Spectar™ copolyester.

General Information

Whether you want to screen print, spray paint, or use any other method to decorate a fabricated sheet of Spectar™ copolyester, the correct ink or paint formulation must be chosen that allows the fully decorated part to meet its intended fitness-for-use requirements. Sheet extruded from Spectar™ copolyester inherently exhibits excellent chemical resistance. Good chemical resistance is generally considered a desired characteristic; however, it is also one of the reasons that ink or paint adhesion to the surface can sometimes be marginal. The proper choice of solvent, in combination with the resin backbone of the ink or paint, is an important concern and should be evaluated by the ink manufacturer using the Scotch®¹ tape adhesion method. Another inherent property of the sheet is its toughness. This property can be compromised by improperly decorating the sheet. The wrong solvent system and/or a rigid film-forming ink or paint system can negatively affect the toughness of the decorated part.

Following these recommendations, alerting your ink supplier to these concerns, and knowing the fitness-for-use requirements of the fully decorated part will minimize these concerns.

Cleaning

Before any piece of plastic can be decorated, it needs to be cleaned and static buildup removed. This is easily done to sheet of Spectar™ copolyester using a 50:50 mixture of isopropyl alcohol and water. As with paints or inks, there are many commercial solutions that can be used to clean and remove static from plastic sheet. It should not be assumed that these solutions can be used on sheet of Spectar™ copolyester. Eastman encourages the use of these mixtures **ONLY** after testing in an inconspicuous area. Apply the commercial mixture according to the manufacturer's instructions and inspect the area for visual crazing and/or hazing of the sheet surface.

Printing Inks and Substrates

Thermoplastic substrates are impervious, or nonporous, and normally require specific ink formulations for quicker drying and better adhesion. Solvent- and water-based inks, as well as ultraviolet and electron-beam curable inks, are available for most plastic printing processes. Enamel, epoxy, acrylic, polyester, and polyurethane-based inks are commonly used for polymers.

¹Scotch® is a trademark of 3M.

Surface Tensions

For better wetting, the surface tensions of the inks should be lower than that of the plastics being printed.

Water-based inks typically have higher surface tensions than solvent-based inks. Water-based inks can be adjusted with alcohol to lower their surface tension for improved wetting and adhesion. Work with experienced ink suppliers—it is easier to adjust the ink than the substrate.

Corona surface treatments can be applied to Eastman Spectar™ copolyester. The treatment increases the surface tension and surface polarity resulting in improved adhesion.

Static Control

Static control is an important issue when printing on thermoplastic substrates. Excess static may cause blocking in sheet-fed operations. Inconsistent ink laydown in inkjet, laser, and similar printing techniques may also be attributed to static charge. Grounding the equipment and substrate, using static eliminator bars and forced deionized air blown onto the substrate, have proven to alleviate these problems.

Choosing Inks or Paints

Before choosing an ink/painting/decoration technique, the end use requirements need to be well understood and conveyed to the printer, ink manufacturer, paint formulator, etc. Many commercially available inks and paints can be used to decorate sheet of Spectar™ copolyester. The solvents chosen to formulate most inks or

paints do not decrease the physical properties of the sheet. Generally, the chosen resin in the ink or paint formulation will compromise the physical properties of the sheet to a greater extent than the solvents in the formulation. There are always adhesion concerns with any ink or paint after the coating is applied to a plastic substrate. It is extremely important that adhesion be tested after the chosen ink or paint has been applied **AND is fully cured!** Eastman recommends testing for adhesion after the samples can be physically handled and have been cured in an oven for 48 hours at 50°C. Usually the Scotch® tape adhesion test is performed (ASTM D3359-B). This is done by etching a “checker board” pattern on the decorated sheet and attempting to remove the paint or ink in the etched area with tape. The test calls for Scotch®¹ 610 tape to be used and a brisk, steady pull should be performed. The dried ink or paint film should be hard to remove by this method.

Work at Eastman has shown that the “flexibility” of the dried film, whether it is ink or paint, is an important characteristic for adhesion and retention of sheet toughness. Dried ink or paint films that remain flexible at high and low temperatures seem to adhere better to the sheet and help maintain sheet toughness better than “rigid” film-forming ink or paint systems. This is only important if the fitness-for-use requirements of the decorated sheet require the decorated part to be subjected to abuse or rough handling. A rigid film-forming ink system, when applied to sheet of Spectar™ copolyester, should be expected to behave in a more brittle manner than a flexible film-forming ink system. If the fully

¹Scotch® is a trademark of 3M.

decorated fitness-for-use sheet of Eastman Spectar™ copolyester is a point-of-purchase display where impact isn't a major concern, most any ink will meet the needs of this application. In this case, adhesion to sheet of Spectar™ copolyester will be the only consideration.

Testing Ink or Paint

1. Coat or print samples of the chosen ink or paint on sheet of Spectar™ copolyester. (Include a flood coat if necessary.)
2. Cure or dry the prepared samples per the ink manufacturer's recommendations.
3. Check adhesion (ASTM D3359-B) before and after aging in an oven at 50°C (122°F) for 48 hours.
4. Check the impact of aged samples at room temperature and 210°C (410°F) using ASTM D3763.

Recommended Ink or Paint Suppliers

Coats Screen (a division of Sun Chemical)

Attention: Curt Baskin
Telephone: 630-513-5348

Nor-Cote International

Attention: David Church
Telephone: 765-362-9180

Nazdar

Attention: Darrell Willis
Telephone: 913-422-1888

Spraylat

Attention: Tony Ricca
Telephone: 914-699-3030

Sun Chemical

Attention: Brian Chwierut
Telephone: 708-932-4517

Fujifilm Sericol

Attention: Mark Cosstell
Telephone: 14-634-8892

Spray Painting

Conventional spray-painting techniques are often used to decorate large panels. There are commercial spray paints available for sheet of Spectar™ copolyester. When selecting paint, carefully consider fitness-for-use requirements such as dry film adhesion and impact strength retention. Obtain more detailed information about these characteristics from the paint supplier.

Dry Film Adhesion

Sheet of Spectar™ copolyester generally exhibits excellent chemical resistance compared with other plastic sheet materials. As a result, some solvent-based paints designed for use with polycarbonate or acrylic may not be sufficiently active to provide good adhesion to sheet of Spectar™ copolyester. Generally, a paint that produces a flexible, tough dry film, such as some polyurethanes, has better adhesion than one yielding a rigid, brittle film. Contact your paint supplier for details.

Impact Strength

The excellent impact strength of sheet of Spectar™ copolyester accounts for its use in a host of demanding applications. It is important that such fitness-for-use requirements be clearly communicated to the paint supplier. Contact your ink or paint suppliers for recommendations on what to use with PETG.

Spray-Masking

Conventional spray-masking materials work well with sheet of Eastman Spectar™ copolyester. Compared with acrylic or polycarbonate, it may be easier to cut away the masking since parts formed from sheet of Spectar™ copolyester usually exhibit crisper forming detail to guide the knife. When cutting the masking, use a sharp knife and minimum pressure to avoid cutting into the plastic sheet, as this may notch the sheet, reducing its impact resistance.

Printing

Many printing processes can be used with sheet of Spectar™ copolyester. The process depends largely on the configuration, production volume, and fitness-for-use requirements of the finished part. Specially formulated inks are available to meet the specific requirements for a given end use. Consult your ink supplier to determine the best choice of inks and application techniques.

Hot-Stamping

Copy, trademarks, and other design elements may be transferred to flat, smooth surfaces on sheet of Spectar™ copolyester by hot-stamping. Eastman has found die temperatures of 149°C to 204°C (300°F to 400°F) and a 1 to 2 second dwell time at 0.62 MPa (90 psi) a good starting place. Additional information on hot-stamping can be obtained from foil manufacturers.

Vinyl Decorating

Benefits of vinyl decorating sheet of Spectar™ copolyester include uniform color distribution and correct color matches. Also, vinyl can be applied to first and second surfaces prior to forming.

General Summary of Fabricating and Forming Sheet of Eastman Spectar™ Copolyester

Eastman Chemical Company's recommendations are based on experience working with sheet of Spectar™ copolyester.

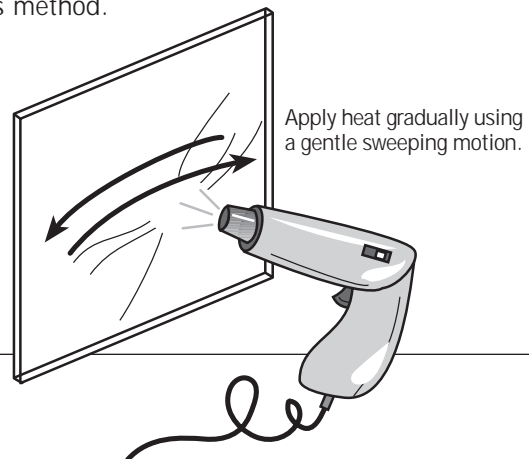
Sheet Storage and Handling

- Store sheet at room temperature in a dry area, not directly exposed to sunlight or heat.
- Make certain the masking film is not removed prior to use, as normal dust and dirt will be attracted to the sheet because of static electricity. The masking will also prevent scuffing and scratching.
- To prevent warpage, the sheet should ideally be stored flat, as delivered. If vertical storage is necessary, it is best to store at a slight angle with support underneath.

Fabricating

- Most tools suited for plastics are best, but tools for wood or metal may be used.
- **Cold-bending**—Cold-brake bending can be used to produce simple shapes. The most attractive bends are obtained **with thickness less than 1/8 in. (3.0 mm)**. The radius of cold bends should be no less than 100 times the initial sheet thickness.
- **Hot-bending**—An electric strip heater with optimum sheet temperature of 107°C (225°F) may be used.
- **Sawing**—Circular, band, saber, jig, and hand saws are suitable. Triple-chip blades offer the best performance for circular saws.
- **Drilling**—Drill bits designed for plastics are suggested.

- **Shearing**—Can be cut using a sheet metal shear with sharp blades. Typically, shear-cutting less than 1/8 in. (16.5 mm) gauge yields the best visual results. Quality of the sheared edge depends on the shearing machine's tolerances, cutting capacity, and blade "rake" angle.
- **Punching**—Can be punch-cut with best visual results **at gauges less than 1/8 in. (3.0 mm)**. Quality depends on the punching machine's tolerances, cutting capacity, and blade "rake" angle.
- **Routing**—To obtain the best routing results, use two-flute twisted cutters.
- **Common heat gun** can be used to eliminate scratches. Care must be taken to avoid warping. Practice on noncritical areas first. Light surface scratches can easily be removed from sheet of Spectar™ copolyester by applying heat from a handheld torch (typically butane or oxygen/hydrogen) or an electric heat gun. To remove shallow scratches it is best to apply the heat evenly with several passes lengthwise over the scratch. To avoid overheating or damaging the sheet, care should be taken to not focus the heat in a constant position. Though this technique works for light surface scratches, deep scratches or gouges in the material's surface are not suitable for repair by this method.



- Sheet of Eastman Spectar™ copolyester may be:
 - **Mechanical-polished**—Edge-finishing using mechanical polishers¹ is best done by starting with as flat an edge as possible (such as from jointing or routing after sawing—sawed edges are difficult to finish because of the roughness) and then using fairly light pressure on the part and a constant feed rate across the polishing surface.
 - **Flame-polished**—For best results, use a **cooler flame (butane or propane)** after the sawed edge has been deburred, jointed, routed, and/or diamond edge-polished. Polishing is best when using a uniform rate of movement and is very technique dependent. Flame treatment can embrittle the sheet edge.
 - **Solvent-polished**—Use methyl ethyl ketone (MEK) or methylene chloride. Avoid spillover and poor technique. This is more difficult with Spectar™ copolyester than with acrylic sheet.
- **Hot-stamping and heat transfer printing** are good decorating methods. Various foils and transfer decals have been used successfully.

Thermoforming

- **No need to dry** the sheet before thermoforming.
- Readily formable by conventional techniques, including traditional vacuum-forming, bending (cold or hot), and a variety of plug-assist, pressure, bubble, and snap-back methods.
 - Use **lower oven temperatures** 200°C–260°C (400°F–500°F) than used for PMMA and PC.

- Use **lower mold temperatures** <50°C (<120°F) than used for PMMA or PC.
- Sheet temperatures of 135°C–155°C (275°F–310°F) are recommended with an optimum temperature being 150°C (300°F).
- Use plug-assist methods for deep-draw molds.
- Use a moderate draft angle (>3°–5°) on molds to aid release of the final part.
 - Remove the part at lower temperatures [less than 65°C (150°F) to prevent part warpage.

Bonding

- **Solvent**—For solvent bonds that are clear, long-lasting, strong, tough, and bubble-free, use commercial products such as Caseway SC125, MC-Bond, Weld-On® 3 and 4.¹
- **Don't** use the regular solvent systems designed for polycarbonate or acrylic.
- **Adhesives**—Start with a flat surface. For adhesive bonding prepare the sheet properly:
 - Lightly sand with fine-grit sandpaper to improve adhesion.
 - Wipe the surface with a 50:50 mixture of isopropyl alcohol and water.
 - Allow to dry thoroughly before bonding.
 - Suggested adhesives include Weld-On® 40, Weld-On® 42, and Weld-On® 58.²

¹Diamond polishers are available from Mutronic (Tel: [0049] 8362/930900) or Edge Finisher Corp. (Tel: [1] 203-796-7923).

²Weld-On® is a trademark of IPS Corporation.

Decorating Sheet of Eastman Spectar™ Copolyester

- **Spray-painting**—When selecting paint, carefully consider fitness-for-use requirements such as dry film adhesion and impact strength retention. Obtain more detailed information about these characteristics from the paint supplier.
- **Dry film adhesion**—Avoid solvent-based paints designed for use with polycarbonate or acrylic. Generally, a paint that produces a flexible, tough dry film, has better adhesion than one yielding rigid, brittle film. Contact your paint supplier for details.
- **Spray-masking**—Conventional spray-masking materials work well with sheet of Spectar™ copolyester. When cutting the masking, use a sharp knife and minimum pressure to avoid cutting into the plastic sheet, as this may notch the sheet, reducing its impact resistance.
- **Printing**—Many printing processes can be used with sheet of Spectar™ copolyester. The process depends largely on the configuration, production volume, and fitness-for-use requirements of the finished part. Specially formulated inks are available to meet the specific requirements for a given end use. Consult your ink supplier to determine the best choice of inks and application techniques.
- **Vinyl Decorating**—Benefits of vinyl decorating sheet of Spectar™ copolyester include uniform color distribution and correct color matches. Also, vinyl can be applied to the first and second surfaces prior to forming.

¹FDA regulation 21 CFR 177.1315 (b) (1)

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