

JUNE 2005

Imago™
Fabrication Techniques

KnollTextiles

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

CONTENTS

Introduction	iii
General Health and Safety Precautions	1
Handling and Storing Imago Sheet	3
Cleaning and Care of Imago	5
Machining Techniques	7
Machining Guidelines	7
Sawing	8
Drilling	9
Milling	10
Routing	11
Tapping	12
Shearing and Punching	12
Die Cutting	13
Forming Techniques	17
Cold Bending	17
Hot Bending	17
Thermoforming	18
Drape Forming	19
Matched-Mold Forming	21
Mechanical Forming	22
Fastening and Adhesion Techniques	23
Mechanical Fastening	23
Bonding Techniques: Solvents Adhesives (Cements)	23
Laminating	26
Seams	26

Finishing Techniques	29
Sanding	29
Joining	29
Ashing, Buffing, and Polishing	29
Filing	30
Water-resistant Treatment	30
Edge Treatment	31
Self Edging	31
Edge Bending	32
V-Groove Forming	34
Mitered Edge	35
Terms and Conditions of Sale	37

INTRODUCTION

Imago™, from KnollTextiles, is made through a patented process, in which fabric is encapsulated in a high-performance resin called PETG (polyethylene terephthalate glycol-modified). This is a glycol-modified version of PET, which is a member of the polyester family and widely used for soft drink bottles.

Through the outstanding properties of PETG, Imago offers excellent performance attributes, combining very high strength with amazing flexibility. The KnollTextiles fabrics provide a range of designs, surfaces, and colors, as well as varying degrees of opacity.

Some Imago standard products come with a “hard coat” finish on each side. This hard coat surface provides additional resistance to scratching, as well as allowing for easy clean-up from ink and most other substances. Imago products with this hard coat finish are well-suited for markerboard use, provided the surface is not textured. When heat bending with a hard coat finished sheet, additional care may be required.

Other Imago standard products come with surfaces textured in a number of ways. These products inhibit scratch appearance through their texture, though should not be specified for markerboard use.

Imago is available in gauges from 1/16- to 1/2-inch, and may be customized in other ways.

For further fabrication information about Imago, please contact KnollTextiles Customer Service:

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Lubin Building
Water Street
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Imago sheets are made to order; orders are non-cancelable and non-returnable. Please see page 37 for Knoll’s Terms and Conditions of Sale and Warranty information.

GENERAL HEALTH AND SAFETY PRECAUTIONS

Always exercise good, safe shop practices when fabricating or forming Imago sheet. Heat generated during sawing, machining, forming, and finishing operations can burn unprotected skin. Use caution to protect operators from flying particles. Provide proper ventilation when using solvents. Adhere strictly to all instructions in Material Safety Data Sheets provided by equipment and materials suppliers. Keep tools sharp and in good working order for safe and high-quality work. Always work in a well-ventilated area, especially when solvent bonding or cementing. Provide localized exhaust venting in the work area.

Safety Guidelines

Do:

- Wear goggles, hearing protection, gloves, and protective clothing as appropriate.
- Keep tools sharp and equipment in good repair.

Don't:

- Work in areas with inadequate ventilation.
- Proceed without first reviewing appropriate Material Safety Data Sheets.

HANDLING AND STORING IMAGO SHEET

Imago sheet is typically shipped with a protective film masking (usually blue or milky white). Imago sheet should be stored flat with this masking intact. Storage areas should be clean, dry, cool, and well ventilated. Use older stock first, since the adhesion of the masking may increase with time. Remove any adhesive residue with a clean, soft cloth dampened with isopropyl alcohol. 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.

Formed parts will continue to cool after they are removed from the mold. To prevent deformation, provide proper support during cooling. This is especially important with large parts.

NOTE: Upon receipt, check your order to verify that it matches the control sample provided by your specifier. If you have any doubt whether you have received the correct product, call your sales representative immediately.

All KnollTextiles products are inspected prior to shipment. Since KnollTextiles is not responsible for damage in shipment or in storage, customers should carefully inspect all items at time of delivery and note any obvious damage on the delivery receipt. For the customer's protection, such obvious or subsequently discovered concealed damage must be reported immediately to the carrier. Claims on Imago sheet will not be considered if the sheet has been worked by the customer or others. No claims for labor charges will be allowed in any circumstances.

Handling and Storage Guidelines

Do:

- Carefully inspect the sheet at time of delivery and note any obvious damage on the delivery receipt.
- Ascertain front and back of sheet before working.
- Store Imago sheet horizontally, with support under full sheet.
- Keep masking in place for as long as possible.
- Keep sheet as clean as possible during storage. Both sides of Imago should be kept free from grease, wax, dust, and chips that could leave impressions through the protective film.
- Store sheet indoors, in a dry, cool, well-ventilated area.
- Avoid exposure to heat 150°F (65°C) or greater.
- Keep table tops clean to avoid scratching the sheet.
- Before cutting the sheet, remove and inspect the whole sheet for defects, then recover for protection during fabrication.
- Wear gloves when handling sheets to prevent cuts.

Don't:

- Use a knife or scraper to remove masking.
- Store Imago sheet near radiators, steam pipes, or in direct sunlight.

CLEANING AND CARE OF IMAGO

Once fabrication is complete and the protective film is removed the care of Imago becomes very simple. Remove dust and dirt with a soft cloth or sponge and a solution of mild soap or liquid detergent in water. If further cleaning is necessary, a 1:1 solution of isopropyl alcohol and water works well.

Always use a soft, damp cloth and blot dry. (Rubbing with a dry cloth can scratch the material and create a static charge.) 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.

In addition, Imago can be cleaned with most household or commercial non-abrasive cleaners, including: Windex, PineSol, and bleach solutions. Many solvent cleaners will not damage the surface if used sparingly.

Never use scrapers or squeegees on Imago sheet. Also avoid scouring or abrasive compounds, acetone, benzene, gasoline, carbon tetrachloride, toluene, deicing fluids, lacquer thinner, or other strong solvents.

Cleaning and Care Guidelines

Do:

- Use warm water, mild detergent, and a soft cloth, sponge, or chamois.
- Use plenty of water to prevent scratching, avoiding immersion of edges where fabric is exposed.
- Blot dry with slightly damp, soft cloth.

Don't:

- Expose to temperatures greater than 150°F (65°C).
- Use scouring compounds or solvents such as acetone, benzene, gasoline, carbon tetrachloride, or lacquer thinner to clean Imago sheet.
- Use abrasives or highly alkaline cleaners.
- Use scrapers, squeegees, or cloth of synthetic fiber such as rayon or polyester as this may scratch the sheet.
- Use hand polishing or power buffing to remove scratches.
- Use the surface of Imago for cooking with appliances like griddles and woks that would make the surface of Imago hot.
- Use the surface of Imago as a cutting surface.

CAUTION: Never use abrasive pads or abrasive cleaners on Imago.

MACHINING TECHNIQUES

The manufacture of products from Imago, an engineered thermoplastic resin, may involve secondary fabrication operations, including sawing, drilling, forming, bending, assembling, lamination, and edging. This publication covers the properties and characteristics of Imago that need to be taken into account if secondary operations are to be performed successfully.

MACHINING GUIDELINES

Imago can be worked with most tools used for machining wood or metal. Tool speeds should be such that the Imago sheet does not melt from frictional heat. In general, the highest speed at which overheating of the tool or sheet does not occur will give best results.

It is important to keep cutting tools sharp at all times. Hard, wear-resistant tools with greater cutting clearances than those used for cutting metal are suggested. High-speed or carbide-tipped tools are efficient for long runs and provide accuracy and uniformity of finish. Bring the blade to full speed before starting the cut. Secure sheet during cutting operations to minimize vibration.

Since engineered resins are poor heat conductors, the heat generated by machining operations must be absorbed by the tool or carried away by a coolant. (A jet of air directed on the cutting edge will aid in cooling the tool and removing chips.) Plain or soapy water is sometimes used for cooling unless the trim scrap is to be reused. Another method of reducing heat is by making several passes while cutting or trimming the part rather than trimming “deep” through the part.

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

Cutting and Drilling Guidelines

Do:

- Leave the original masking on the sheet during cutting operations.
- Practice on pieces of scrap before cutting parts.
- Use recommended saw blades.
- Use sharp, clean blades and bits.
- Use slow, consistent feed rate.
- Hold sheet firmly while cutting to minimize vibration; use just enough clamp pressure to prevent vibration.
- Use compressed air to minimize heat buildup, especially for sheet more than 3/16 in. thick.
- Feed against the rotation of the blade or tool.
- Wear proper safety equipment.

Don't:

- Cut or drill with a dull blade, cutter, or bit.
- Apply excessive clamping pressure.
- Use a blade with side-set teeth.
- Scribe-break Imago sheet.
- Remove safety guards from equipment.

SAWING

Any of the following saw types, commonly used for wood or metal, should be satisfactory for cutting Imago sheet: circular saws, band saws, saber saws, jigsaws, hacksaws, or hand-saws. However, some saw designs are better suited than others for sawing Imago because they produce smoother or faster cuts. Circular saws and band saws usually produce the best surfaces, and they can be used in most sawing operations.

Blade design plays an important part in successful sawing of Imago sheet. A skiptooth band saw blade is preferred because the wide gullet provides ample space for the plastic chips to be carried out of the kerf (the cut made by the saw). For best results, the teeth should have zero rake and some set. For a curved cut, the blade should be narrower and have more set than for a straight cut. The blade must be kept sharp to prevent melting or chipping of the sheet, and the blade guide should be placed very near the cut to minimize vibration.

A circular saw is preferred to a band saw for straight cuts even though it tends to generate more heat. A circular saw should be operated at approximately 8,000 to 10,000 linear ft. (2,400 to 3,000 linear m) per minute with carbide-tipped saw blades having three to five teeth per 1 in. (25.4 mm) and should have plenty of set or be hollow ground. A perforated saw blade will run cooler than a solid blade. It is essential that the spindle bearing be tight so that the saw will run true.

Several different types of blades have been evaluated for each type of saw, and the following suggestions are made based on the smoothness and general cut appearance. The saw blades listed in Table 1 are commercially available.

NOTE: Be sure to hold or clamp the part securely while sawing to prevent chattering, which can cause cracking.

Table 1
Sawing Recommendations

Type of Cut	Tool	Blade Type	Blade Parameters	Blade Speed
Straight	Circular saw	T.C. & F./TC	10-in. (254-mm) diameter, 80-tooth carbide tipped 5 degree rake positive	4,500 rpm
	Band saw	0.5 in. (12.7 mm)	3 to 6 teeth per 1 in. (25.4 mm), skip	2,000 ft./min. 610 m/min.
	Saber saw or Jigsaw	Finish cutting blade	7 teeth per 1 in. (25.4 mm)	
	Handsaw	Crosscut	8 or 10 pt.	
Curved	Band saw	0.5 in. (12.7 mm)	3 to 6 teeth per 1 in. (25.4 mm), skip	2,000 ft./min. 610 m/min.
Trimming and deflanging	Router	Carbide tipped, Double fluted	0.375-in. (9.5-mm) diameter straight	23,000 rpm
	Radial arm or Table saw	10 in. (254 mm)	80 teeth, triple chip grind	3,450 rpm

DRILLING

Drills designed especially for plastics are available and their use is suggested on Imago. Standard twist drills for wood or metal can be used; however, they require slower speeds and feed rates to produce a clean, non-gummed hole. 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.

Twist drills used for plastics are suited to working Imago—they should have two flutes, a point with an included angle of 60 to 90 degrees, and a lip clearance of 12 to 18 degrees, as shown in Figure 1.

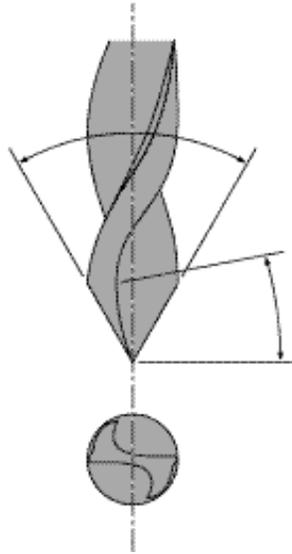


Figure 1
Suggested Drill-Point Design for Drilling Imago Sheet

Wide, highly polished flutes are desirable since they expel the chips with low friction and thus tend to avoid overheating and consequent gumming. Drills with substantial clearance on the cutting edge of the flutes make smoother holes than those with less clearance. Drills should be backed out often to free chips, especially when drilling deep holes. Peripheral speeds of twist drills for plastics ordinarily range from 100 to 200 ft. (30.5 to 61 m) per minute. The rate of drill feed into the plastic sheet generally varies from 0.010 to 0.025 in. (0.254 to 0.635 mm) per revolution.

NOTE: When drilling be sure to hold or clamp the part securely to prevent it from cracking or slipping and presenting a safety hazard to the operator.

MILLING

Imago sheet can be machined with standard high-speed milling cutters for metal, provided they have sharp edges and adequate clearance at the heel.

Climb cutting is a milling operation that gives a good machined finish on Imago. In climb milling, the work moves in the same direction as the rotating cutter. Satisfactory results can be achieved using a 0.625-in. (15.9-mm) diameter bit at 500 rpm with a travel of 5 in. (127 mm) per minute. Climb milling requires lubrication with plain or soapy water.

Table 2
Troubleshooting Guide for Cutting Operations

Problem	Possible Cause	Possible Solution
Rough or chipped edges	High feed rate	Reduce feed rate
	Sheet vibration	Secure sheet firmly
	Blade protrusion	Limit to maximum of 0.125 in. (3.175 mm)
	Broken teeth	Replace blade
	Blade too coarse	Use more teeth/in. (mm)
Cracking	Blade and fence not parallel	Realign blade and fence
	Sheet vibration	Secure sheet firmly
	Feed rate too high	Reduce feed rate
Surface scratching	No masking	If possible, leave masking intact
	Dirty work surface Jigs/fixtures are nicked, burred	Clean work surface File, sand, or polish to remove remove burrs
Blade gums up	Dull blade	Sharpen or replace blade
	Inconsistent feed rate	Use steady, even feed rate
	Feed rate too slow	Increase feed rate
	Improper blade	Use blade specified
Dust buildup	Dull blade	Sharpen or replace blade
	Clogged blade	Clean or replace blade
	Static charge on sheet	Wipe with damp cloth
	Masking removed	Leave masking in place

ROUTING

Routing with sharp two-flute straight cutters produces very smooth edges. Routers are useful for trimming the edges of flat or formed parts, particularly when the part is too large or irregular in shape for a hand saw. Portable, overarm, and under-the-table routers work equally well. The Imago sheet should be fed to the router slowly to avoid excessive frictional

heating and shattering. The router or sheet, whichever is moving, must be guided with a suitable template. Compressed air can be used during the routing operation to cool the bit and aid in chip removal.

TAPPING

Conventional four-flute taps can be used for cutting internal threads in Imago sheet when a close fit is required. Such taps, however, have a tendency to generate considerable heat during the tapping operation. A high-speed, two-flute tap should offer longer life and greater tapping speed than a conventional tap, as well as provide clearance for chip discharge. Flutes should be ground so that both edges cut simultaneously; otherwise the thread will not be uniform. Cutting edges should be 85 degrees from the centerline, giving a negative rake of 5 degrees on the front face of the lands so that the tap will not bind in the hole when it is backed out. It is desirable to have some relief on the sides of threads.

SHEARING AND PUNCHING

Shearing and punching are suitable methods for cutting Imago sheet. A shear will produce a straight-edged cut whereas a punch can produce holes of almost any desired shape.

Power shears can be used to cut 1/16-in. gauge Imago sheet; for thicker sheet, saw cutting is preferable. It is important to maintain a blade-to-bed knife clearance of approximately 0.001 in. (0.0254 mm) for a smooth cut.

Punches may be used when a fairly rough edge is satisfactory. Hand-operated punches are useful for small holes; however, power operated punches are normally used for holes larger than approximately 0.25 x 2 in. (6.35 x 50.8 mm). Cracking and chipping can be reduced by heating the sheet to approximately 100°F (38°C); however, some allowance for hole shrinkage due to cooling may be necessary. Sawing, drilling, and routing are preferable to punching when thicknesses are greater than approximately 1/16 in.

Shearing, Punching, and Die Cutting Guidelines

Do:

- Heat sheet to 100°F (38°C) before punching.
- Insure entire die is level and true before cutting.
- Shim areas as necessary to insure uniform cut.
- Use carbon paper imprint to set die properly.

Don't:

- Shear sheet thicker than 1/16 in.
- Die cut sheet thicker than 1/8 in.
- Use a dull die.
- Use a steel cutting plate harder than 30 to 35 Rockwell C.
- Use power equipment without proper safeguards.

DIE CUTTING

Imago sheet gauge 1/8 in. or less can be cut satisfactorily with steel rule dies, which are ribbons of steel that may vary from 0.030 to 0.100 in. (0.76 to 2.54 mm) in thickness by 0.5 in. (12.7 mm) wide and are sharpened on one edge. They are generally mounted in slots of appropriate shape that are cut into wood blocks and are relatively inexpensive. The steel rule must be sharpened or replaced fairly often.

Figure 2 depicts two steel rule designs that work equally well in sheet gauges up to 1/8 in. Hardness may vary from 45 to 55 Rockwell C and can be dependent on the degree of bending required in fabrication.

Presses designed for die cutting should be adjusted to cut completely through the Imago sheet with a stroke that will stop before damaging the cutting rule. A make ready procedure is used to shim areas of the die to ensure that all areas cut through the sheet uniformly. All presses should have a softer steel cutting plate (30 to 35 Rockwell C) to prevent contact with the press bed.

The cutting surface is normally a 0.020- to 0.125-in. (0.51- to 3.175-mm) thick steel plate. A 6- to 8-mil (0.15- to 0.20-mm) kraft/carbon paper is taped to the plate, and the die is then carefully lowered so that the entire cutting area is marked. Test die cutting is then alternated with shimming of rule areas until a full, uniform cut through the sheet is obtained.

It is also important to cut in the same place each time and to keep the cutting dies as sharp as possible.

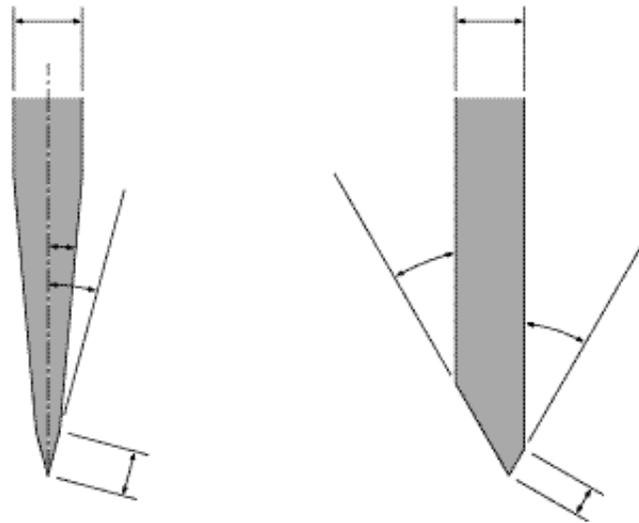


Figure 2
Steel Rule Designs

Figure 3 illustrates a typical setup for using a steel-rule die. A shearing assembly is shown in Figure 4.

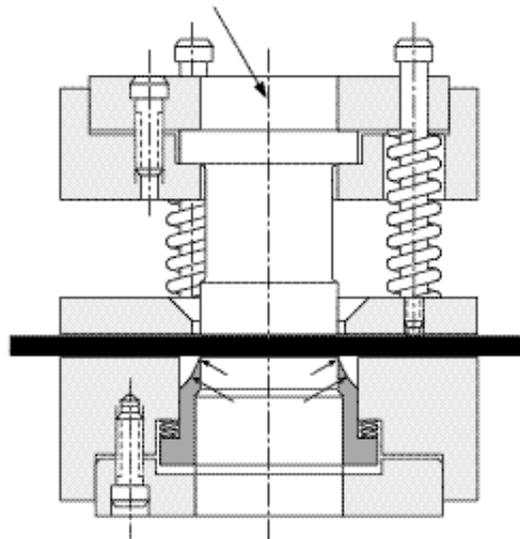


Figure 3
Diagram of Steel-Rule Die Assembly

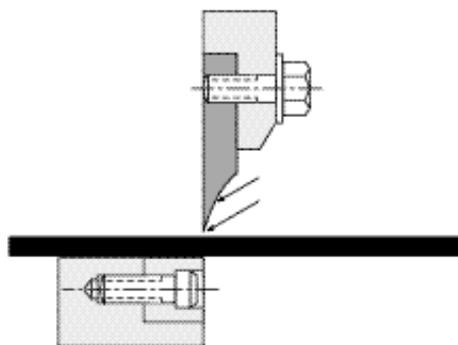


Figure 4
Diagram of Shearing Assembly

Table 3 reflects the shear strengths, as determined in accordance with ASTM D 732, required to cut various thicknesses of sheet.

Table 3
Shear Strength Recommendations

Sheet Thickness, in.	Shear Strength, psi (MPa)
1/16	8,300 (57.2)
1/8	8,200 (56.5)
1/4	6,700 (46.2)

A die press must have adequate power to achieve the desired cut. The shear strengths shown in Table 3 can be used with the following formula to calculate the required die press tonnage:

$$F \text{ (tons)} = \frac{\text{Shear strength (psi)} \times \text{perimeter of cut (in.)} \times \text{thickness (in.)}}{2,000 \text{ lb./ton}}$$

For example, a 15- x 15-in. sheet of 1/8-in. thick Imago sheet requires a shear strength of 8,200 psi. The press tonnage required to die-cut a sheet measuring 15 in. square is calculated below:

$$F = \frac{8,200 \text{ psi} \times 60 \text{ in.} \times 1/8 \text{ in.}}{2,000 \text{ lb./ton}} = 30.75 \text{ tons}$$

FORMING TECHNIQUES

Some Imago sheet has an abrasion resistant coating (hard coat) and needs to be treated differently than uncoated sheet. Contact your sales representative if you are not certain whether your product has a hard coat finish.

Hard coated sheets that are textured show the effects of heating less than the polished and satin finishes.

Always test form a sample to determine workability before forming your final piece.

COLD BENDING

Imago sheet (gauges 1/8 in. and less) can be cold bent or brake formed to produce simple shapes from Imago sheets. (A cold bent piece will hold its new shape once bent.) The permissible degree of bending is dependent on both sheet thickness and rate of deflection. Cold bending of gauges more than 1/16 in. will likely result in high stress levels.

All gauges of Imago can accomplish a radiused curve if held in position, for example in a track. (The sheet will not retain this shape unless help in place.) Table 4 indicates minimum radii possible for available sheet thicknesses in a restrained application.

Table 4
Minimum Attainable Radii in Restrained (track-type) Application

Sheet Thickness, in.	Radii Minimum, in. (mm)
1/16	6 (152.4)
1/8	12 (304.8)
3/16	18 (457.2)
1/4	24 (609.6)
3/8	30 (762)
1/2	36 (914.4)

HOT BENDING

Imago sheet can be bent on a small radius by preheating an area on one or both sides with an electric strip heater and then quickly bending the sheet along the heated line.

Hard-coated and textured Imago can be heat bent, but should be heated only on the side opposite to the hard coat or texture. Textured sheet should not be heated above 260°F (127°C) to prevent deformation of the texture. Textured sheet that is heat bent may not retain uniform surface texture across the bend.

Thicker gauges—above 1/4 in.—may need to be heated from both sides during the heating cycle. When the optimum sheet temperature is reached—slightly over 225°F (107°C)—

and a slight resistance to bending is noticeable, the part can be readily formed. If bending is performed too cold, stresses will be created that will result in a brittle part; however, overheating can cause bubbles in the bend area. Test bend a sample piece before working the final sheet.

Strip heaters as shown in Figure 5 are available from plastic supply houses.

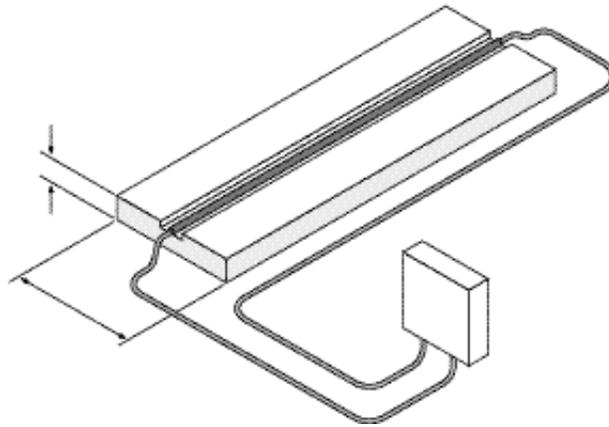


Figure 5
Hot Bending Device

THERMOFORMING

Some thermoforming techniques can be used to force Imago sheet, once heated, into the shape of a mold by mechanical means.

Use only uncoated Imago sheet for thermoforming. Textured sheet can be formed, but texture may not remain uniform across tight bends. Contact your sales representative if you are not certain whether your product has a hard coat finish, or if you any questions about its textured surface.

Tooling can range from low-cost plaster molds to expensive water-cooled steel molds, but cast aluminum is more commonly used. Other materials including wood, gypsum, and epoxy can also be used. Forming processes to be discussed include drape, matched-mold, and mechanical.

Because of the encapsulated fabric in Imago sheet, the overall surface area of the sheet will not change during forming. The sheet must be unclamped before the mold is applied, as Imago will not stretch when formed. A *very shallow draw* is recommended when thermoforming with encapsulated fabric.

Temperature for thermoforming ranges from 240° to 280°F (116° to 138°C). When forming textured sheet, temperature should not exceed 260°F (127°C) to prevent deformation of the texture. Always test a sample piece before forming final part.

Formed parts will continue to cool after they are removed from the mold. To prevent deformation, provide proper support during cooling. This is especially important with large parts.

Forming Guidelines

Do:

- Inspect sheet prior to molding to confirm that you have the correct product and to verify face and back of sheet.
- Keep molds and sheet very clean. Remove dust with a damp cloth or blow it off with pressurized air.
- Provide a 3 to 4 degree draft on male molds for easy release.
- Leave masking in place where possible.
- Form sheet of Imago at lower temperatures (240°-280°F/116°-138°C) than those used for acrylic and polycarbonate.
- Allow parts to cool sufficiently before removing from mold.

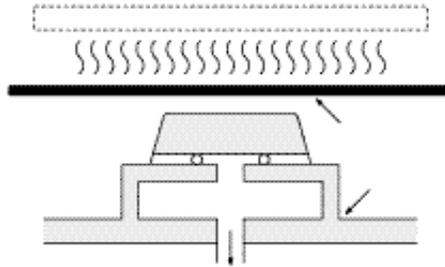
Don't:

- Use coated Imago sheet for forming.
- Heat textured sheet above 260°F (127°C).
- Lay larger formed parts face up while cooling.
- Nest formed parts during storage.

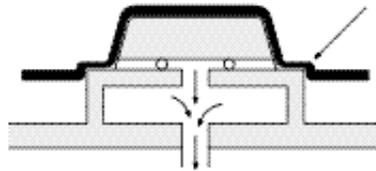
Drape Forming

Drape forming is similar to straight vacuum forming: the Imago sheet is heated, unclamped, a pressure differential applied, and the sheet allowed to set into a large-format male mold (e.g., to form a curved wall or skylight dome). The overall sheet surface area remains constant through the process. Drape forming can also be used with gravitational force alone. See Figure 6 A, B, and C.

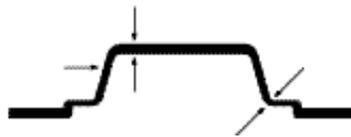
Figure 6
Drape Forming



(A) The heated, unclamped Imago sheet can be pulled over the mold, or the mold can be forced into the sheet.



(B) Once the sheet has formed a seal around the mold, a vacuum is drawn to pull the sheet tightly against the mold surface.

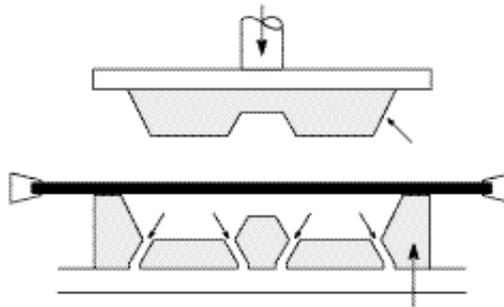


(C) Final wall thickness distribution in the molded part.

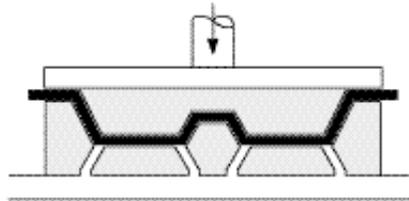
Matched-Mold Forming

Matched-mold forming is similar to compression molding in that heated Imago sheet is trapped between male and female dies made of wood, plaster, epoxy, or some other material. Although they cost more, water-cooled, matched molds produce more accurate parts with close tolerances. See Figure 7 A, B, and C.

Figure 7
Matched-Mold Forming



(A) The heated Imago sheet can be clamped over the female die, as shown, or draped over the mold form.



(B) The heated sheet is unclamped before molding.



(C) Vents allow trapped air to escape as the mold closes and forms the part.

Mechanical Forming

In mechanical forming, neither vacuum nor air pressure is used to form a part. The process is similar to match molding, but close fitting molds are not used. Only the mechanical force of bending or draping the hot Imago sheet (unclamped) is used to form the part. This process can be classed as a fabrication or postforming operation in that a simple wooden jig is used to produce the required shape. Flat stock can be heated and wrapped in cylindrical fashion or possibly bent at a right angle. See Figure 8.

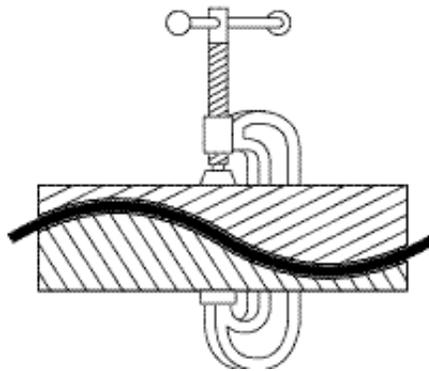


Figure 8
Mechanical Forming

FASTENING AND ADHESION TECHNIQUES

MECHANICAL FASTENING

Imago sheet can be fabricated into attractive joints with mechanical fasteners. Self-threading screws are used if the fastener is not to be removed very often; when frequent disassembly is required, threaded metal inserts are preferred. Mechanical fastening is recommended for assembly of larger articles.

Screws and rivets provide permanent assembly. Standard nuts, bolts, and machine screws are used in many instances; in addition, special screws and rivets specifically designed for use with plastics are suited to use on Imago. Springs, clips, and nuts are low cost, rapid, mechanical fasteners. Hinges, knobs, catches, and dowels are some other devices used in mechanical assemblies.

Mechanical Fastening Guidelines

Do:

- Use screws designed specifically for plastics.
- Drill holes slightly oversized to allow for thermal expansion and contraction.
- Insure drilled holes have smooth edges.
- Use washers for better load distribution.
- Use metal inserts if frequent assembly/reassembly is required.

Don't:

- Overtighten fasteners.
- Use self-tapping screws to hang large panels.

BONDING TECHNIQUES: SOLVENTS AND ADHESIVES (CEMENTS)

Imago sheet can be fabricated into a variety of shapes and articles with solvent or adhesive bonds. In general, when the surfaces to be joined are irregular, an adhesive is preferred over a solvent. Solvents are not the best choice when bonding Imago sheet to other thermoplastics. Adhesives, including cyanoacrylates, two-part acrylics, and hot melts, are more effective when bonding Imago to dissimilar plastics and can be used to bond Imago to itself. Adhesives are preferred when bonding to the surface of hard-coated or textured Imago sheet. Silicone is effective when joints need to retain slight flexibility, may be subjected to changing thermal conditions, or require waterproofing.

Small articles with flat surfaces can be joined by placing the pieces together and applying the appropriate bonding agent (solvent or adhesive). Care should be taken to ensure that the joints are uniformly coated; a solvent can be effectively applied with a needle applicator. The assembly should be clamped into position until the bond is set.

When larger articles are to be joined or fastened, mechanical fastening is recommended.

Table 5 lists several solvents and adhesives that provide strong bonds with good clarity when used in Imago sheeting fabrication operations.

Table 5
Solvents and Adhesives for Imago Sheeting Fabrication

MECO MR AP/35	Adhesive
MC BOND	Solvent Blend
Loctite 408	Cyanoacrylate Adhesive
Perma Bond 910	Cyanoacrylate Adhesive
Perma Bond 268	Cyanoacrylate Adhesive
RWH 29	Solvent Blend
Weld-On 3	Solvent Blend
Weld-On 4	Solvent Blend
Weld-On 7	Solvent Blend
Weld-On 40	2-Part Adhesive
Weld-On 55	2-Part Urethane Adhesive
Union Camp 2690	Polyamide (Hot-Melt) Adhesive
National Starch 34-9002	Reactive Polyurethane (Hot-Melt) Adhesive
Scotch 4950	Double-Coated, Pressure-Sensitive Foam Tape
Scotch 4941	Double-Coated, Pressure-Sensitive Foam Tape

Bonding Guidelines

Do:

- Start with a flat surface.
- Insure sheet edges and surfaces are clean and free from contamination. Wipe surface with a 1:1 mixture of isopropyl alcohol and water. Allow surface to dry thoroughly before bonding.
- Insure that surfaces to be bonded are smooth, mate well, and are accurately aligned.
- Press together the surfaces to be bonded.
- A solvent or adhesive must be sufficiently active to soften the mating surfaces for some flow to occur when pressure is applied.
- Apply solvent to edge of joint with a hollow needle. Solvent will wick into joint by capillary action.
- Hold joints in a horizontal position to prevent solvent from pooling at one end.
- Use minimum amount of solvent needed to wet surfaces to be bonded.
- Use a jig or fixture to securely hold parts being bonded together while curing.

Do (continued):

- Work in a climate-controlled area with low humidity to minimize joint “whitening.” If this is not possible, the addition of ten percent glacial acetic acid to the solvent or use of a slower curing, cement-type bond is suggested.
- Work in well-ventilated area when working with solvents. Exposure levels must be controlled according to OSHA guidelines.

Don't:

- Use solvents to bond sheet of Imago to other materials such as acrylic or polycarbonate.
- Use solvents when bonding to the surface of hard-coated or textured Imago sheet.
- Use MEK (methyl ethyl ketone), THF, or Weld-On 7 for edge bonds.
- Flood the joint as this can cause hazing.
- Leave gaps where solvent can pool.

For information about bonding Imago to ABS, acrylic, polycarbonate, or other materials, consult an adhesive supplier. Knoll does not recommend any particular supplier. Some vendors include:

Caseway Industrial Products
14516 New Hampton Place
Ft. Myers, FL 33912 USA
Tel: 941-561-1021

IPS
455 West Victoria Street
Compton, CA 90220 USA
Tel: 800-421-2677

Dymax Corporation
51 Greenwoods Road
Torrington, CT 06790 USA
Tel: 860-482-1010

Lord Corporation
Industrial Adhesives Division
2000 W. Grandview Boulevard
Erie, PA 16514-0038 USA
Tel: 814-868-3611

Poly Sciences, Inc.
Valley Road
Warrington, PA 18976 USA
Tel: 215-343-6484

National Starch & Chemical
10 FINDERNE AVENUE
BRIDGEWATER, NJ 08807 USA
Tel: 908-685-5000

AAM Manufacturing
1755 Hubbard Drive
Batavia, IL. 60510 USA
Tel: 630-406-9600

LAMINATING

Imago can be applied to a substrate like many other laminates. Certain precautions should be taken because of the unique physical characteristics of Imago (hard coat and textured finishes). Always test a sample piece before forming final part.

The best method to laminate Imago to a substrate is with the use of contact adhesives. The selection of adhesive is critical to performance of the product (see Bonding Techniques, above). When working with large panels, and a strong waterproof bond to the substrate is required, use a solvent-based translucent contact adhesive, e.g., Hybond 80.

Recommended steps for laminating Imago:

- Inspect sheet for color and gauge and remove any protective film from back side.
- Precut sheet, allowing 0.25 in. (6.35 mm) overhang for flush trim part. When sawing Imago take precaution that the sheet is held down tight to saw table so that there is no vibration as the sheet passes through the blade. Excessive vibration causes chipping and cracking of the cut edge.
- Scuff sand the back side of Imago to aid adhesion. This can be done with a belt sander using an 80-grit belt, or on a large scale using a wide belt sander and running the entire 4- x 8-ft. (1.22- x 2.44-m) sheet through at one time.
- Apply glue to both the substrate and back side of Imago at the same time. Allow time for the adhesive to set. Check the adhesive manufacturer's requirements for drying. Many adhesives are solvent based. Use precautions to ventilate the work space when using solvent-based adhesives.
- Apply Imago to the substrate allowing a minimum overhang of 0.125 in. (3.175 mm). Once the two pieces are together roll with a J roller or pinch roll to secure the bond between the sheet and panel.
- For general quality work it is recommended that panels receiving Imago on the face be laminated on the back with a balance sheet of laminate or a backer sheet.
- Imago can also be laminated over drywall, plaster, and masonry.

SEAMS

Imago provides many advantages when sheets are put together edge to edge. In vertical and horizontal applications a reveal may be desirable because of the visibility of the seams.

The following recommendations should be followed in making seams in vertical and horizontal applications. (For bonding recommendations, refer to Bonding Techniques, above.)

- Machine "factory edges" to ensure true edges without chips (see Machining Techniques, above).

- For a more flexible and durable seam, bevel or radius the edges slightly to soften the corners.
- Locate the seams in Imago so they aren't directly over the seams in the substrates.
- Mask off the finished edge of Imago in the area where you are making seams to keep the edge clean. Before putting together the seams, apply a very small bead of silicone or 2-part adhesive, such as Weld-On 40, to fill the gap between the two sheets. Apply just enough to fill the gap without pushing out onto the finished surface of the sheet. The silicone can be cleaned off after seaming but Weld-On 40 must be sanded off which will damage the surface of the sheet.
- Beveled strips of Imago or trim pieces can be placed over seams. Secure strips using silicone held by masking tape until silicone sets.
- Place adhesives or sealant in the areas where the edges join.

See Figures 9, 10, and 11.



Figure 9
Beveled Strip Seam



Figure 10
Beveled Seam



Figure 11
Radius Seams

FINISHING TECHNIQUES

Imago sheets are manufactured to a specified finish—*only the edge surfaces* should be sanded, ashed, buffed or polished. When finishing, care should be taken to avoid exposure of the sheet edges to excessive moisture that could wick through the Imago sheet. The use of solvents or heat to polish edges is not recommended.

Finishing Guidelines

Do:

- Use carbide or high-speed blades.
- Use consistent feed rates.
- Use files with coarse, single-cut teeth (on edges of sheet only).
- Wet-sand edges to avoid excessive heat buildup.
- Wear proper safety equipment.

Don't:

- Apply abrasives or attempt to heat polish the surface of the Imago product—only edges can be finished.
- Employ solvents or heat.

SANDING

The edges of Imago sheet are best sanded wet to avoid the frictional heat buildup that is characteristic of dry sanding techniques. If water coolants are used, the abrasive lasts longer and the cutting action is increased. Progressively finer abrasives are used; for example, rough sanding with 80-grit silicon-carbide would be followed by finer sanding with 280-grit silicon-carbide, wet or dry. The final sanding may be with 400- or 600-grit sandpaper. After the sanding is finished and the abrasives removed, additional finishing operations may be required.

JOINING

A standard woodworking jointer-planer will produce an accurately aligned and good quality finished edge on Imago sheeting. Carbide or high-speed blades, which have a longer life, provide a uniform finish as well. Since excessive stock removal per pass could result in rough edges, a cut of 0.015 in. (0.38 mm) or less per pass is suggested. For best appearance, use a consistent feed rate.

ASHING, BUFFING, AND POLISHING

Only the edges of Imago sheet can be ashed, buffed, and polished.

Ashing, buffing, and polishing are accomplished on abrasive-charged wheels made of cloth, leather, or bristles. When a coolant is used, finishing wheel surface speeds of 35 to 45

ft. (10.7 to 13.7 m) per second are suggested; when the wheel is operated dry, lower speeds should be used.

Ashing is a finishing step in which a wet abrasive such as number 00 pumice is applied to a loose muslin wheel. Surface speeds of 65 to 70 ft. (19.8 to 21.3 m) per second are typical since overheating is not a problem in this process.

Buffing is an operation in which a grease- or wax-filled abrasive bar is applied to a rotating muslin wheel. Loose buffs are used for more irregular shapes or for entering crevices. The most common buffing abrasives are tripoli, rouge, or other fine silica.

Polishing, sometimes called luster buffing or burnishing, employs wax compounds containing the finest abrasives such as levigated alumina or whiting. Polishing wheels are generally made of loose flannel or chamois. The wax fills many imperfections and protects the polished surface.

FILING

When many thermoplastics, including Imago, are filed, a light powder that tends to clog some files is produced. Therefore, aluminum type A, shear-tooth, or other files that have coarse, single-cut teeth with an angle of 45 degrees are preferred. Curved tooth files like those used in auto body shops clear themselves of plastic chips. Files should only be used on the edges of Imago sheet.

WATER-RESISTANT TREATMENT

If the Imago product will be exposed to moisture, a silicone sealant can be applied to the edges.

EDGE TREATMENT

When working with Imago a wide selection of edge types are available for your projects:

- Self Edging
- Edge Bending
- V-Groove Bending
- Mitered Edging

SELF EDGING

Self edging is the application of an edge covering on the edge of a panel. The edge can be Imago that matches the top surface or a contrasting color. Other material can also be used in the self edge treatment. For example:

- Hardwood
- Decorative metals
- Solid surface material
- Vinyl edges
- T-slot laminate colors

When bonding self edges, apply a clear or nearly clear contact adhesive. (Examples: Fastbond #30 NF by 3M is a water soluble adhesive that works well for edges; Scotchgrip 4693 is a clear contact adhesive that works well on edges.) Imago strips can also be applied with edge banding equipment and hot melt adhesives.

The self edge can be applied before or after the top surface is applied, depending upon the final look desired.

To apply an edge before a top surface is applied:

- Cut the edging material to size. Allow 0.125-in. (3.175 mm) overhang.
- Glue the edge piece and the edge of the panel. Join the two parts together after the adhesive has had time to set.
- Apply pressure to edge by rolling with a J roller. Imago can also be applied with good quality edge banding equipment and hot melt adhesive.
- When sanding the top of the edge use a stiff pad to avoid warping around edge. Draw the sander towards the substrate to avoid pulling the edge off and/or chipping the edge. Make certain all the dust is removed before gluing on the top surface.

- B. When edging after the top surface is applied allow enough time for the sheet to return to optimum temperature before doing final trimming of the top sheet. Sometimes the sheet will shrink after being applied or bent.
- Trim top surface with a flush trimming router bit.

- When the top surface is trimmed and sanded, the edge of the top and the edge strip can be glued using clear contact adhesive.
 - Allow adhesive to set, then apply the edge to panel, trim flush, and radius with a router.
- C. Following edge application, edges can be cleaned up using rubbing alcohol, scraper, and dual action sander using 320-grit paper. The scraper can be drawn over the edge to take off any burrs, then the sander can smooth the edge. Once the edge is cleaned and sanded it can be lightly buffed to remove sanding marks. Use care not to sand the finished surface of Imago—only edges can be sanded or buffed.

EDGE BENDING

Imago can be formed around the edge of a substrate after being heated on an electric strip heater. Note that surface textures may not remain completely uniform across the bend. Scoring the back of the Imago sheet may produce a smoother turn (see V-Groove Bending, below). Test bend a sample before working on final sheet.

CAUTION: Do not heat bend Imago that is treated with a hard coating; hard coated Imago can show surface cracking on the coated surface when heated.

- Peel back the top protective coating from the area you are heating. Be sure the surface is clean and dry.
- Once the material is at bending temperature (225°F/107°C) you have 10 to 15 seconds to move it off the heater and rotate the part onto the top of a flat surface near the heater.
- Next, fold the Imago around the edge of the substrate and hold until cool.
- While cooling, place the part in an area that is smooth and free of dirt and chips that would leave an impression on the hot plastic.
- The bent part can be clamped into position during the cooling time. The bent part will shrink for several hours following the heating and bending procedure. Wait until shrinkage occurs before laminating, final cutting, or trimming.
- Laminate Imago sheet to substrate once the part is cooled.
- Trim or cut to final dimension.

CAUTION: The sheet surface and heater are extremely hot. Use caution to avoid touching either surface.

Different thicknesses of Imago take different amounts of time to heat. Different heaters will also affect the time of heating. It is best to do some test bends to establish a feel for the time and method of bending. A tight radius bend on 1/8-in. Imago takes around 60 seconds. See Figure 12 below.

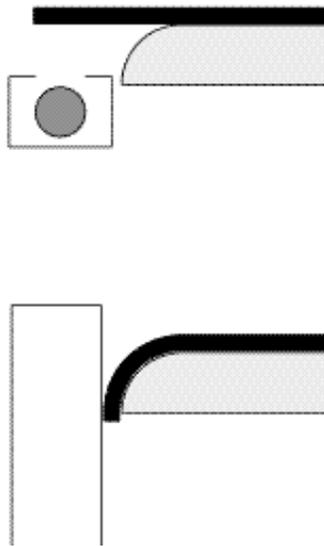


Figure 12
Hot Bending Imago to a Substrate

Larger radius bends can be made using a wide face heater (2 to 6 in./50.8 to 152.4 mm). Hold Imago tightly around these bends so that the finished surface is smooth and straight.

Factors to consider when bending Imago over a large radius:

- Insure that the form is smooth and consistent.
- Allow enough time for the part to cool.
- Allow for shrinkage in the part.
- When heating a larger area of Imago, the finish in the area that is heated can change from that of the rest of the sheet.

V-GROOVE FORMING

Another technique for bending Imago is to cut a V-groove in the back of the sheet part way through the sheet. This is necessary only on thicker sheets (1/4 in. and up). This grooving reduces the time required to heat and bend the part. The V-groove is cut before the part is applied to the substrate. Cut the V-groove using a router or a special grooving blade on a table saw. See Figure 13 below.

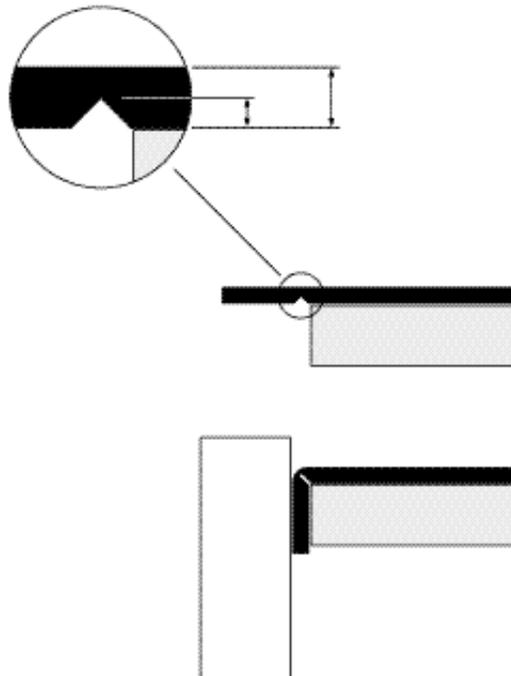


Figure 13
Bending with a V-groove

MITERED EDGE

This technique allows application of an edge to all sides of a panel and the elimination of the glue line produced by a self edge. Once mastered, this technique fabricates an attractive edge on Imago without heat bending, and allows the use of Imago's hard coated surface. We recommend using this process on the thickest gauges of Imago, 1/4 in. and up.

First, laminate the Imago sheet onto the substrate, leaving an overhang edge of 0.0625 in. (1.59 mm) more than the thickness of the sheet of Imago. Using a special 45-degree cutter and guide that follow the edge, trim the edge of the piece so that the edge is 45 degrees up and out from the top edge of substrate. Cut the edging material using a straight edge as a guide in the same way as above.

Clear or color matched silicone or a thick adhesive can be applied in the area where the miter comes together to seal that area. The edge piece is bonded with contact adhesive. See Figure 14 below.

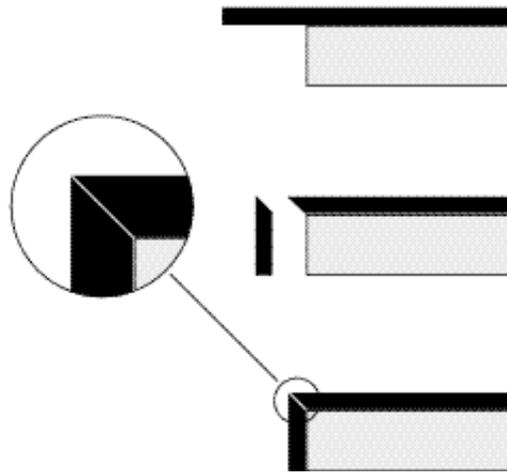


Figure 14
Mitered Edge

ImagoPrints™ and Imago™ Terms and Conditions

Orders

Order all Imago and ImagoPrints sheet by name and number where indicated. Fax orders to 866-565-5860.

Order Confirmation

The acknowledgement or seller's invoice is the final expression of the agreement between the customer and KnollTextiles and supersedes all prior oral and written statements regarding the order. The confirmation can be modified only in writing or reconfirmation signed by KnollTextiles. Minimum order quantity for standard product is one sheet (4 foot x 8 foot).

KnollTextiles' Imago and ImagoPrints are sold by the sheet (4 foot x 8 foot). Call 866-565-5858 for availability, minimums and pricing.

Change Orders

KnollTextiles is not required to accept requested change orders. However, as a general rule, KnollTextiles will accept reasonable change orders with the following conditions:

1. The request for change must be submitted in writing and received in time to be implemented.
2. Changes will be subject to additional charges for material, labor and administrative costs.

Cancellations

Orders are non-cancelable and non-returnable. Imago and ImagoPrints are made to order.

Damage Claims

All KnollTextiles products are inspected prior to shipment. Since KnollTextiles is not responsible for damage in shipment or in storage, customers should carefully inspect all items at time of delivery and note any obvious damage on the deliver receipt. For the customer's protection, such obvious or subsequently discovered concealed or damaged must be reported immediately to the carrier. Claims on Imago and ImagoPrints will not be considered if the sheet has been cut, formed, or worked by the customer or others. No claims for labor charges will be allowed in any circumstances.

Prices

Published textile prices are net 30 days, provided customer meets Knoll's standards for open credit terms, F.O.B., KnollTextiles Operations Center, East Greenville, PA, 18041.

Prices do not include:

1. Shipping/Handling charges
2. Storage of insurance charges
3. Sales and other taxes
4. Local delivery, uncrating and installation

Credit

Imago and ImagoPrints always require a minimum 50% deposit. Credit may be established upon KnollTextiles written acceptance of satisfactory data/references. KnollTextiles may cancel or change credit terms at its discretion and may request advance payment at any time. All prepaid orders must include shipping and handling charges and tax where applicable. If local taxes are not applied on prepaid orders, customers must complete a resale certificate, indicating their tax I.D. number.

Availability

All product discussed in this price brochure are subject to changes in availability and/or price at any time, with or without notice.

Shipping

We will ship in accordance with customer instructions. Unless the customer specifically requests in writing partial shipments as completion occurs, KnollTextiles may await completion of entire order and ship on a specified basis or may take partial shipments from time to time. All Imago and ImagoPrints shipments will be made F.O.B., Palisades, Fla.

KnollTextiles is not liable for any delay or failure to deliver or perform due to strikes, lockouts or other labor difficulties, failure or delay sources of supply, transportation difficulties, accidents, fires, acts of God, or any other causes of like or unlike nature beyond KnollTextiles control.

All KnollTextiles' shipments are made on a dock to dock basis, or a sidewalk delivery. Please contact your KnollTextiles regional office if you require additional services, i.e. inside delivery. This will be a separate charge and handled on a regional basis when available. The Knoll Traffic Department will determine from the "ship to" destination the recommended method of shipment. Unless complete instructions as to shipping method and route are stipulated by the customer, we have the option to ship by, what is in our opinion, the best possible way.

Claims

All claims against KnollTextiles such as claims for shortages and errors must be made in writing within 10 days after delivery. The facts on which the claim is based must be directed in writing to the KnollTextiles regional sales office.

Failure to make such a claim against KnollTextiles within a 10-day period shall constitute acceptance of the merchandise and waiver of any shortages, errors or other claims.

Cutting, forming, or working of the product will be deemed acceptance of the shipment and waiver of all defects, shortages, errors and that the correct color/pattern has been received. KnollTextiles gives no warranty, expressed or implied, as to description, quality, merchantability, fitness for any particular program, or any other matter, of any Imago or ImagoPrints product which KnollTextiles shall supply.

Knoll warrants to the original purchaser that all Imago or ImagoPrints products under normal wear and tear shall meet the specifications listed in the current technical literature under each products name, including lightfastness, and flame retardant rating for a period of (1) year with remedies as follows: should any failure to conform with this limited warranty appear on the product during the first year after the date of shipment, upon prompt written notice, Knoll will repair or replace, as its option, the affected Imago or ImagoPrints product only.

This warranty does not apply to:

Acts or omissions of parties other than Knoll.

User modification.

Unusual atmospheric or environmental conditions.

Misuse of product.

Purchasers remedies set forth herein are exclusive and the liability of Knoll with respect to the breach of this agreement or any contract entered into between the parties pursuant hereto shall not exceed the price of the Product or part on which such liability is based. ALL OTHER WARRANTIES INCLUDING ANY IMPLIED WARRANTY OR MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY DISCLAIMED. KNOLL, ITS CONTRACTOR, AUTHORIZED DEALERS AND SUBCONTRACTORS OR SUPPLIERS OF ANY TIER SHALL NOT BE LIABLE TO PURCHASER FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES ARISING FROM BREACH OF THIS AGREEMENT.