

Technical manual, January 2005

Vivak[®] and Axp[®] Solid Polyester Sheets

Machining

1. General remarks

Tools

Vivak[®] and Axp[®] sheets can be machined using the standard tools commonly used for metal and woodworking. We recommend carbide-tipped tools. Above all, it is important to use sharp cutting tools with the right geometry.

Cooling

No cooling is required during the normal machining of Vivak[®] or Axp[®] sheets. In the event of local overheating during machining – e.g. when drilling through very thick materials – we recommend cooling with water or oilfree compressed air.

Oil emulsions and cutting oils should not be used when machining Vivak[®] or Axp[®] as these may contain additives to which Vivak[®] or Axp[®] is not resistant, resulting in stress crack formation.

Dimensional accuracy

The coefficient of linear expansion of Vivak[®] or Axp[®], at 0.04 - 0.05 mm/mK, is significantly higher than for metal or glass. For this reason, dimensions should always be checked at room temperature.

Remember that shrinkage of approx. 3 to 6 % depending on thickness occurs when the material is heated above the glass transition temperature (approx. 80 °C) for the first time.

Protective Masking

Vivak[®] and Axp[®] sheets are provided with a PE masking film to protect the smooth surfaces from damage during transport and fabrication.

Please leave the film on the sheet during machining. Solar radiation and weathering may influence the properties of the film and make it very difficult to remove later on (possible formation of adhesive residues).

Our **standard protective masking film is not suitable for exposure to thermal loads**, and does not allow thermoforming with good results. The film should therefore be removed from the sheets before processes such as drying, hot line bending and/or thermoforming.

We have specially manufactured, unprinted grades of film that allow the sheets to be fabricated with the protective masking left on.

Marking

Marking out drill holes, cut edges etc. should be done on the protective film. If marking is required, use a soft pencil or felt-tip pen. Marking tools should not be used as the tracing mark has a notching effect, and a higher load at this point may cause the sheet to crack.

Technical manual, January 2005

**Vivak[®] and Axp[®]
Solid Polyester Sheets**

Machining

2. Sawing

Hand saws

Standard hand saws may be used to cut Vivak[®] or Axp[®] sheets. A saw with fine spacing between the teeth should be used.

Circular saws

Using a circular saw is the easiest way to cut Vivak[®] and Axp[®] sheets. Experience has shown that carbide-tipped circular saw blades produce the cleanest cuts. The spacing varies from fine for thin sheets to coarse for thicker materials. Ensure that no shavings are left on the cutting surface as these could damage the protective film and scratch the sheets.

When handling sheets less than 2 mm thick use a thick underlay board or a pair of shears instead of a circular saw.

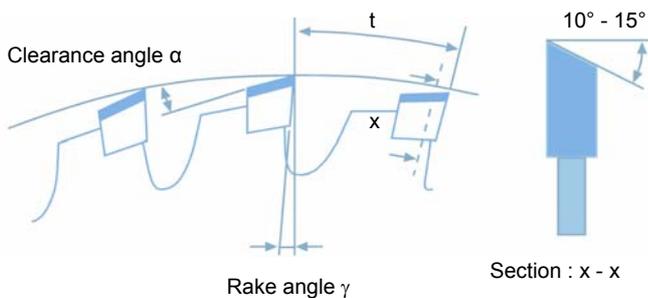


Fig. 1: Circular saw blade

Ribbon saws

Ribbon saws are ideal for curved cutting of formed parts or irregular shapes. To achieve a clean cut edge it is important to work on a solid cutting surface. A wide spacing is required when working with thick materials.

For higher quality cut edges, circular saws or milling cutters achieve a better result than ribbon saws.

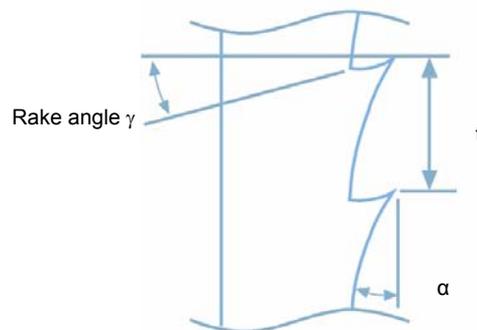


Fig. 2: Ribbon saw

Trouble-shooting

Fused cut edge:

- Check tool sharpness
- Check cutting speed and reduce if necessary
- Check rate of advance and reduce if necessary
- Cool if necessary

Notched cut edge:

- Check tool sharpness
- Check tool geometry
- Improve cutting surface (use an underlay if necessary)

Technical manual, January 2005

**Vivak[®] and Axpet[®]
Solid Polyester Sheets**

Machining

	Ribbon saw	Circular saw
Clearance angle α	20 - 40°	10 - 30°
Rake angle γ	0 - 5°	5 - 15°
Cutting speed v (m/sec)	600 - 1.000	1.000 - 3.000
Spacing t (mm)	1.5 - 3.5	2 - 10

3. Cutting and punching

Vivak[®] sheets up to 3 mm thick and Axpet[®] sheets up to 1.5 mm thick are easy to cut and punch, producing a good cut result. How thicker the sheet, the poorer the quality of the cut and the greater the risk of cracking. Good results can be obtained using a sharp shearing tool with a wedge angle of max. 30°, with clearance between the tool and the cutting surface of 0.01 to 0.03 mm (see Fig. 3)

If you require smooth cut edges it is better to saw or mill Vivak[®] and Axpet[®] sheets with a thickness of 1.5 mm upwards.

When punching close-tolerance holes, allowance must be made for shrinkage if machining is to be followed by heat treatment of over 80 °C. This means that the hole should be measured approx. 5 % larger than actually required. How bigger the hole and the thicker the sheet, the lower the tendency for the sheet to shrink. Good results are obtained using symmetrically ground shearing tools.

For punching/cutting Vivak[®] and Axpet[®] sheets that are more than 1.5 mm thick, we recommend asymmetrically ground blades. To achieve right angles, blades ground on one side with a wedge angle of 30° should be used. Make sure that the base plate (polyamide or polyethylene HD-PE with a high molecular weight) remains in place and is properly centered with the punching tool to ensure clean cut edges.

Fig. 3: Clean cut edges

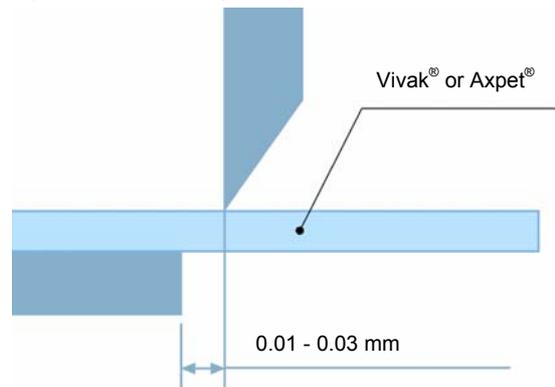
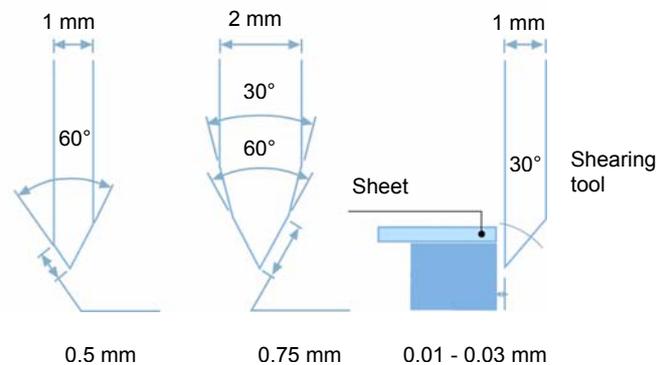


Fig. 4: Depending on sheet thickness, various different types of cutter are recommended for punching.



Technical manual, January 2005

**Vivak[®] and Axp[®]
Solid Polyester Sheets**

Machining

4. Drilling

Standard drills used for metalworking are perfectly suitable for machining Vivak[®] and Axp[®]. Make sure that the cutters on the drill are sharp. Cooling during drilling is generally not necessary.

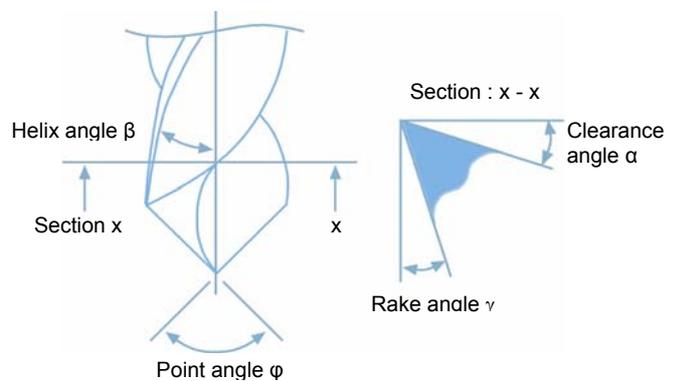
When working with relatively large drilling depths we recommend using water or compressed air and/or regularly withdrawing the drill from the hole to reduce heat and remove shavings.

Oil/water emulsions or cutting oils should not be used when drilling through Vivak[®] and Axp[®] sheets. Standard circle-cutting equipment (e.g. circle cutters or compass saws) is suitable for large-scale drilling. The drill holes should be smooth and as free as possible of notches or rough areas to ensure secure fastening.

Recommended angles for drilling:

Point angle φ	110 - 130°
Helix angle β	19 - 40°
Cutting speed	30 - 60 m/min
Feed	0.1 - 0.3 mm/rev

Fig. 5 Drills for Vivak[®] and Axp[®] sheets



5. Milling

Vivak[®] and Axp[®] sheets are easy to process using milling machines. The choice of milling machine depends on the type of machining required. Ensure that your tool has good chip clearance and sharp cutters.

6. Hinge effect

Axp[®] has a very high level of fatigue resistance, creating scope for a diverse range of hinge effects. By pressing with a blunt blade, pre-punching or milling, it is possible to create the bent edges that may be required on the inside. Sheets up to 1.5 mm thick can be crease line folded or pre-punched whilst V-shaped milling should be used for thicker sheets.

Technical manual, January 2005

Vivak[®] and Axp[®]
Solid Polyester Sheets

Machining

These edges are permanently moveable, on a par with paper or cardboard flaps.

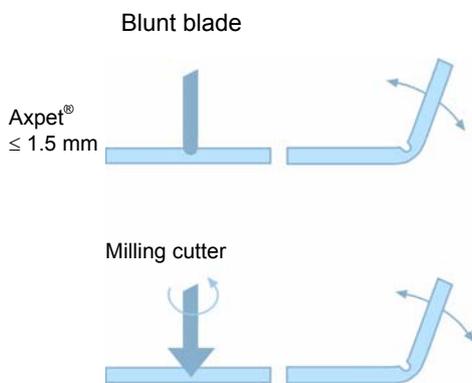


Fig. 6: Hinge effect

7. Laser cutting

Various designs of laser can be used for the thermal cutting of Vivak[®] and Axp[®] sheets – with or without film. Lasers are particular suitable for cutting complex contours. To achieve a bubble-free cut edge, the Vivak[®] and Axp[®] sheets need to be pre-dried after which it is recommended that they be conditioned. Laser beam cutting of Vivak[®] and Axp[®] sheets that are more than 2 mm thick leads to colouring at the edges.

8. Finishing

Flame Polishing

Propane, butane or other types of gas burner may be used for flame polishing. This technique can produce excellent results but requires experience and ongoing practice. Make sure that the material does not crystallize. Cracks may appear in the polished area in the long term.

Polishing

Medium-density riding polishing wheels with a peripheral velocity of 20 to 30 m/s can be used to polish Vivak[®] and Axp[®] sheets with alkalifree polishing pastes.

A clean polishing wheel without polishing paste is then used to complete the polishing process.

Large-surface polishing should be avoided.

Decorating

Before treating polish Vivak[®] and Axp[®] sheets – e.g. by coating, screen printing or thermoforming – we recommend removing any loose particles of dirt or dust adhering to the surface using ionized air.

The **matt side of Axp[®] NR sheets is not suitable** for printing.

Transfer printing

Vivak[®] and Axp[®] sheets and finished parts can be printed using transfer printing.

Technical manual, January 2005

Vivak[®] and Axp[®] Solid Polyester Sheets

Machining

Screen printing

Vivak[®] and Axp[®] may be printed with standard screen printing equipment and inks suitable for thermoplastic polyesters (PET). The ink manufacturer's recommendations should be followed.

Vivak[®] and Axp[®] can be printed with UV-cured inks. The short-term UV radiation has no impact on the physical properties. The maximum application temperature of 65 °C should not be exceeded during the drying process.

Coating

Once cleaned, Vivak[®] and Axp[®] may be coated without any other pre-treatment. Care should be taken to ensure that the coatings and printing inks are chemically compatible with Vivak[®] and Axp[®].

9. Cleaning

Vivak[®] and Axp[®] has a pore-free surface to which it is difficult for dirt to adhere. Dusty parts can be wiped with water, a soft cloth or a sponge but should **never be rubbed when dry!**

For thorough cleaning, we recommend a non-abrasive detergent. Razor blades or other sharp tools, abrasive or strongly alkaline detergents, solvents, leaded benzene and carbon tetrachloride should not be used.

The only way to achieve effective cleaning without streaks is to use a microfiber cloth that is simply dampened with water. In the case of a greater build-up of dirt or greasy stains in particular, benzene-free pure petroleum spirit (cleaner's naphtha or light gasoline) may be applied.

Splashes of dye, grease or residual sealing putting etc. may be removed using a soft cloth soaked in ethyl alcohol, isopropyl alcohol or petroleum ether (boiling point 65 °C) and gentle rubbing prior to curing. Rust marks can be removed with a 10 % solution of oxalic acid.

Vivak[®] and Axp[®] has good electrical insulation properties resulting in electrostatic charging and the attraction of dust particles.

Before treating Vivak[®] and Axp[®] sheets we recommend removing any loose particles of dirt or dust on the surface by blowing with ionized air. The particles cannot be removed using a normal compressed air gun or a cloth but will generally just be moved around