

# Laminate Fabrication Guide

## GENERAL

### Paper and Cotton Fabric Based Grades

The paper based grades are the easiest composites to machine. As a rule, it is machined more readily than metals on standard machine tools such as those used for wood or metal fabrication.

For most machining operations, ordinary high-speed steel tooling is satisfactory. However, where production quantity, production speed or finishes are important factors, carbide-tipped tools often prove more economical to use. Cutting tools must be kept extremely sharp to achieve accuracy and final desired finish.

Paper based laminates are machined dry and cutting compounds and lubricants are not necessary. Cooling by compress air or vacuum at the cutter is preferable to the use of liquid coolants which are difficult to remove from the finished parts. Machine operators should be cautioned to keep the temperature of the work below 150°C, since temperatures above 150° can distort the material and may cause a char on the machined surfaces. Cuttings are readily removed by a vacuum system.

### Glass Based Grades

In many cases, the same machining operations employed in the fabrication of metals and wood may be adapted to the glass based grades. However, certain slight changes in tools and the use of proper speeds are necessary.

Diamond or tungsten-carbide tools will give more satisfactory work with longer, more economical life than high speed steel tools.

## CIRCULAR SAWING

### Paper and Cotton Fabric Based Grades

Circular saws may be used for straight or angular sawing. When smooth edges are required or close tolerances are important, a hollow-ground circular saw without set should be used. For rough cutting, saws with set are satisfactory. Best results are obtained when the saw blade protrudes a minimum distance above the surface of the laminate being cut.

12" diameter saws should be used for material up to 1" thick and 16" saws should be used for thicknesses up to 2.500". It is important that all teeth be square, of the same height, and free from burrs. The cutting edge should run either directly toward or just back of the center hole. In both circular sawing and band sawing, the work should be fed as rapidly as possible without forcing it.

### Glass Base Grades

A diamond impregnated wheel with copper body, 0.062" thick and 12" diameter, run at 3 000 to 3 600 rpm will give good results cutting dry with a good exhaust system. The material is fed by hand into the saw as fast as it will cut without forcing the saw. Idling creates friction and heat, which cause excessive dulling and burning. A flood of water on the work and wheel can be used when necessary to prevent overheating. Abrasive wheel cutting under water is also recommended.

#### Circular Saw Data

Application	rpm	# teeth	diameter	N	T	S
rough cut*	2150	100	16"	0.375"	0.250"	0.125"
smooth cut	2150	200	16"	0.282"	0.562	0.125"
all purpose*	2860	100	12"	0.375"	0.156"	0.125"
tubing cuts	2860	100	12"	0.250"	0.095"	0.062"

\* These saw blades have 0.019" set. Other saws are hollow ground to prevent binding.

## BAND SAWING

### Paper and Cotton Fabric Based Grades

The standard band saw is satisfactory where close tolerances of smoothed edges are not important. It is most effective in sawing blanks for sheet stock.

Saw blades should have between four and seven teeth per inch with some set, the number of teeth depends upon the thickness of the material being sawn. For heavy material, 3" and over, a blade with three teeth per inch is recommended. Operating speeds should be approximately 3 000 fpm and blades should be tempered to permit frequent sharpening.

Width of the blade will vary depending on the radius to be cut. For circular cuts the width should be narrow, but for straight cuts the blade may be up to 1" in width.

### Glass Based Grades

For best results, carbide tipped blades should be used. Work should be fed lightly and the blade should be kept sharp. Sawing can be done dry with a good exhaust system.

## SHEARING

### Paper and Cotton Fabric Based Grades

Standard shears, suitable for sheet metal are recommended in shearing this type of material. The knife blade should be kept sharp and the materials held rigid with a hold-down bar. Most paper based laminates up to 0.062" thick and canvas laminates up to 0.125" thick can be sheared at room temperature, 70 °F minimum.

### Glass Base Grades

Thicknesses up to 0.093" can be sheared. The same standard practices are used as for other laminated plastics.

## TURNING

### Paper and Cotton Fabric Based Grades

Ordinary high-speed tool steel can be used in finishing operations for all phenolic resin systems. However, carbide tipped tools may prove more economical and will hold sizes more accurately from piece to piece. About 0.010" stock should be left for finishing. Laminated phenolics can be turned at 400 sfpm with high-speed steel tools, and about twice that fast with carbide tooling. Tools should be kept sharp, ground with an included angle of 80° to 100°, and with a 10° to 16° side clearance. Cutting should be done dry.

### Glass Base Grades

Conventional machining, such as turning, boring and facing can be done on automatic screw machines, standard and production lathes and hand turret lathes.

Carbide-tipped tools and cutters should be used with surface speeds below those used for paper base laminates. Tools should be ground with a zero rake and machining can be done dry with an exhaust system to remove dust. A coolant can be used, but it is not necessary.

## **MILLING**

### Paper and Cotton Fabric Based Grades

Standard tools may be used at speeds and feeds similar to those for bronze and soft steel. It may be more economical, in spite of higher material cost, to use carbide tools. The cutting angle of the mill will give better results if ground with a slight rake.

### Glass Based Grades

Glass based laminates can be milled very satisfactorily on any conventional metal-working milling machine. Carbide tipped tools should be used. Only climb or down milling should be practiced, as up milling will tend to delaminate the material.

## **DRILLING AND TAPPING**

### Paper and Cotton Fabric Based Grades

A standard high-speed drill with lips backed off to provide maximum clearance is satisfactory for all paper phenolic paper or cotton fabric grades. However, for long production runs and deep holes, carbide-tipped drills give the best performance.

Drills should be lifted from the work frequently to prevent binding and excessive heating. The feed should be light and uniform and the speed of the drill should be considerably in excess of that used for soft steel. With tungsten-carbide tips, speeds may be as high as 16,000 rpm. Where possible, the material being drilled should be backed up with scrap laminate or other soft material to prevent chipping out.

In drilling this material parallel to the laminations, extra care must be taken to prevent splitting. The material should be clamped in a vise or between plates and the drill should be lifted more frequently to remove chips.

Holes 0.750" and over may be drilled in the conventional manner using radial drill presses or the counterbore method in which a pilot hole is drilled first.

Drill size - Due to the nature of thermoset composites, the diameters of holes drilled in laminates are usually 0.002" under the drill size. Therefore, the drill selected should be at least 0.002" larger than the specified diameter of the hole. If the drill being used is dull, the hold size may be an additional 0.002" undersize, or a total of 0.004" less than the diameter of the drill.

The recommendations for drilling also apply to tapping. Taps used for metal are also suitable for this type of laminate construction. Tapping heads or tapping machines may be used, and for production work, collapsible taps are available in sizes over 1.250".

### Tap Sizes

In tapping these materials, high-speed taps 0.002" oversize should be used. The tap drill size should be changed to 0.002" oversize to counteract the tendency of the drill to cut undersize. If the thread is to be used frequently, metal inserts should be used. For threaded holes over 0.500", it is often more desirable to chase the thread on a lathe using a motor-driven cutter mounted on the tool post.

### Glass Based Grades

When drilling glass base grades, a carbide drill should be used. The materials can be drilled dry with a good exhaust system to remove the dust. A flood of water on the work and drill can be used when necessary to prevent overheating and dulling of the drills. High speed drills, nitrate treated, can be used, but must be sharpened more often. Care should be taken when sharpening that it is cut back far enough to the original body diameter of the drill. Spindle speed for these grades is 4 800 rpm for 0.250" diameter drills.

The methods for tapping these materials are much the same for tapping paper base laminated composites. The abrasiveness may cause taps to cut very close to the finished size, resulting in a tendency toward binding when backing out. Standard high speed steel taps can be used on short runs. For any sizable quantity carbide taps should be

used. Taps should be purchased oversize. Coolant can be used, but is not necessary if a good exhaust system is available.

## **THREADING**

### Paper and Cotton Fabric Based Grades

For threaded holes over 0.500", it is often desirable to chase the thread on a lathe, using a motor driven cutter mounted on the tool post.

When cutting a 60° thread, it is advisable to swing the compound reset on the lathe to a 30° angle. The tool is ground to cut on one side only.

For all other threads, standard methods are used with satisfactory results; the speed and feeds are similar to those used in threading soft steel.

### Glass Based Grades

External and internal threads can be cut on a lathe with carbide-tipped tooling, without lubrication. Fine cuts should be taken to give best results.

## **BUFFING**

### Paper and Cotton Fabric Based Grades

Standard polishing rouge on a rag wheel gives good results for these grades requiring a polished surface.

Grinding and sanding may be done by a belt, disk, or centerless methods. No lubrication is necessary.

## **STAMPING AND ENGRAVING**

### All Grades

Laminated thermoset plastic surfaces to be stamped should be smooth. Sanding may be necessary, in some cases, to obtain satisfactory results. Compression presses employing heated dies give best results. Engraving can be done with any standard engraving machines. Tools should be sharp to produce clean-cut edges.

## **WATERJET CUTTING**

### All Grades

Pre-drill holes at pierce locations to prevent delamination.

## **ADHESIVE**

### All Grades

Prep material by sanding and cleaning. Two part epoxy for the appropriate environment.