FABRICATION

Recommended General Fabrication Practices

1. Observe common safety precautions. For example, the operator of a circular power saw should wear safety glasses to protect his eyes.
2. A coverall or shop coat will add to the operator's comfort during sawing, machining or sanding operations. Although the dust created is non-toxic and presents no serious health hazard, it can cause skin irritation. The amount of irritant will vary from person to person and can be reduced or eliminated by use of protective cream.
3. Machine ways and other friction-producing areas should be cleaned frequently. The combination of grease and FRP chips can rapidly become a damaging abrasive if allowed to accumulate.
4. Avoid excessive pressure when sawing, drilling, and routing, etc. Too much force can rapidly dull the tool. (Diamond or carbide grit edge saw blades, carbide tip drill bits and carbide router bits are recommended).
5. Do not generate excessive heat in any machining operation. Excessive heat softens the bonding resin in the FRP – resulting in a ragged rather than a clean-cut edge. Excessive heat can also burn resin and glass.
6. Support the FRP material rigidly during cutting operations. Shifting may cause chipping at the cut edges. Proper support will also prevent any warping.
7. Consider carefully the use and design of fastening devices for mechanical connections.
8. For adhesive fastening ***prepare the surface properly for bonding*** prior to the application of the adhesive.
9. The strongest connection of high reliability can be made by using a combination of mechanical fasteners with adhesives.
10. Always touch-up or seal any cut surfaces or edges of the FRP shape before reporting the job complete.
11. Examples of typical connections are shown on back cover.

MACHINING

Sawing or Cutting

Always provide adequate support to keep the material from shifting when making a cut. Without adequate support, FRP reinforced profiles will chip.

In cutting operations, use light evenly applied pressure. Heavy pressure tends to clog the blade with dust particles shortening the cutting life of the blade. Cutting speed is a critical variable. If the part edges begin to fray or turn black, slow the cutting speed.

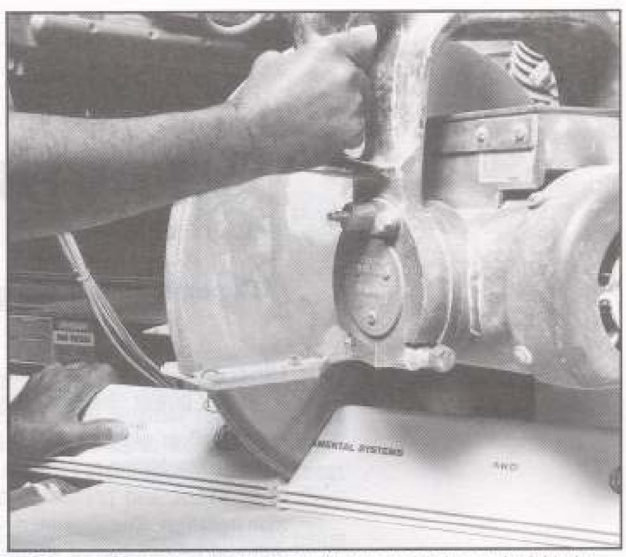
Water cooling is desirable when many pieces or thick cross sections are being sawed. With cooling, cutting speeds increase, smoother cuts result, and dust is often eliminated. However, water contaminate disposal is a consideration.

Deciding whether to saw Exel Composites structurals with a hand or power saw depends, among other things, on the quantity being cut. When sawing relatively few pieces, a disposable-blade hacksaw (24 to 32 teeth per inch) is suitable. Although an ordinary carpenter's saw can be used, frequent resharpening makes this tool less desirable. Remington grit edge blades can also be used in a hacksaw.

Straight line sawing (vacuum hood raised).

Straight Line Sawing

Straight line sawing of Exel Composites structurals can be accomplished quickly and accurately with a circular power saw. A table or radial model is better than a portable hand model because of the built-in rigidity and guides which insure accurate cuts. However, a hand model can also be effective.
A wood cutting circular saw blade can be used to cut FRP but is not recommended. If used, it will require frequent sharpening. Carbide tipped blade is not recommended as it will vibrate during use and will sling teeth after a period of use.
A carbide or diamond grit edge blade is recommended for circular saw cutting of FRP parts. For high volume production cutting, a 60 to 80 grit diamond blade will provide best results.
One problem that may be encountered with a circular power saw is that large sections cannot be cut in one pass due to the blade size. However, many large sections can be sawed in two passes by cutting halfway through from one side, inverting the material and cutting the other side.



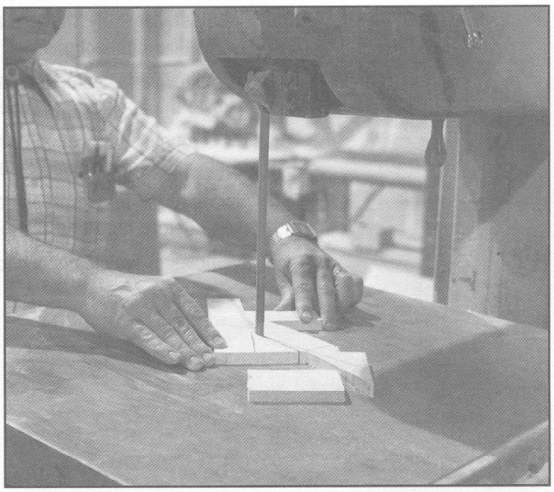
Cross cutting with radial arm saw (circular) and diamond grit blade.

If the cross section is too large for the circular saw tow-pass method, or if large sections are being sawed in quantity, use a power band saw with a carbide or diamond grit edge blade – preferably a machine with automatic feed to insure a light, even pressure on the blade. In the cutting of tubing, a smoother cut can be made if the tube is "rolled through".

MACHINING

Circular or Curvature Sawing

Good results can be obtained using a saber saw or band saw on small quantity cutting. For large volume production sawing *use carbide or diamond grit edge blades* to avoid excessive blade replacement.



A band saw is ideal for cutting circles, irregular shapes and large shapes.

A hand router with rotary bit can also be used to cut circles and curves – but it removes considerably more stock.

In cutting rod or bar stock, a hacksaw may be convenient. A blade with 24 to 32 teeth per inch is effective for hand cutting and light steady strokes should be used.

Abrasive blades (carbide or diamond), which may have become clogged because of overheating or too much pressure, may be cleaned by cutting a common brick.

For large holes, a hole saw is preferable to a fly cutter.

Punching

FRP can be easily punched; however, the ability to punch is dependent upon thickness. FRP will spring back, unlike the bending properties of metal. The amount of tonnage required for punching FRP is also somewhat less than that of aluminium, especially on a thinner part.

The best possible punching results can be obtained using a specially shaped punch that permits only a small part of the cutting edge to penetrate the material at any one time. The punch should be equipped with a stripper system so that it can be removed without cracking the FRP material around the hole.

Procedure: the abrasiveness of Exel Composites structural shapes must be compensated for in the method of punching.

1. The punches will need to be sharpened often.
2. The dies will need to be replaced or sharpened.
3. The overall tooling life may be shorter than the equivalent for metal punching.
4. It is common for punched holes in FRP to be drilled out again in a secondary procedure when dictated by tight tolerances.

MACHINING

The FRP material will make dust and chips. A clearance of .001 inches is not good enough. Dust will clog up the female die almost instantly. Thus, a punch would quickly be off-centre. The minimum clearance should always begin at .005 inches. For high-production lines or thicker sections of 3/16 inch or more, you will often have a clearance of .010 to .020 inches.

All plastics are not the same. Extremely close tolerances can be maintained for some thermoplastics but polyester, vinyl ester and epoxy thermosets are not as predictably tight. Tolerances often have to be generous. Mat-reinforced FRP (thermoset) can be punched to closer tolerances than those containing high roving loadings. It is normal for fibres to "spring back" after punching and partially "close" a hole.

Reinforced FRP is resilient. The hold-down systems should be designed very carefully to compensate for this resiliency – strippers are mandatory.

Silicones may be used to lubricate the punch. This lubrication will gather the fibre and dust particles, thus quickly jamming up the punch. Keeping the machine and area clean at all times should eliminate this problem.

Allow for variance in part as called out in our standard tolerances in the Exel Composites Design Manual.

Some useful guidelines for Punching are:

1. Oversize all holes by .020 to .030 inches.
2. The punched holes will range from .010 to .020 inches smaller than the punching die. For riveting, punched holes occasionally have to be re-drilled – especially in parts with thickness of ⅛" or thicker.
3. Surfacing materials, like mat and scrim, will produce a very clean punch.
4. When punching hollow shapes, use strong counter supports, such as: (1) Mandrills, or (2) Bottom carriage rests.
5. For high-production runs, especially on parts that are .125 inches thick or thicker, a lubricant may be necessary.

Shearing

Shearing is not recommended unless your shear is equipped with a specially shaped blade that allows only a small portion of the cutting edge to penetrate the FRP material at any one time. Shearing will not be as precise as sawing but it is a fast cutting method. Do *not* shear Exel Composites shapes over 3/16" thick. Some of the precautions listed in Punching apply for shearing.

Drilling

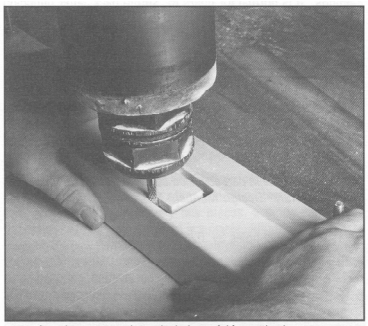
Any standard high speed steel drill bit can be used for drilling Exel Composites FRP shapes; *but will require frequent sharpening. Carbide tipped drills* are recommended when drilling large quantities. Drill speeds should be approximately equivalent to those used for drilling hardwood. When drilling large holes, a backup plate of wood will reduce the break out on the back side of the hole.

Important Note for Close Tolerance Work: Holes drilled in Exel Composites structurals are generally .002" to .004" undersize. For example: a ⅛" drill will *not* produce a hole large enough to admit a ⅛" expanding rivet. Instead, a No. 30 drill should be used.

Routing

Both hand held and bench type routers give excellent results. Rotary file bits – preferably carbide or diamond tipped – are best when routing on production quantities. Two fluted wood bits can be used, but they require frequent sharpening and are therefore practical only for occasional routing.

Caution: Use a light pressure when making a cut. Forcing the routing operation causes the FRP to heat and soften – and you may damage the bit or the part of the bit becomes clogged.

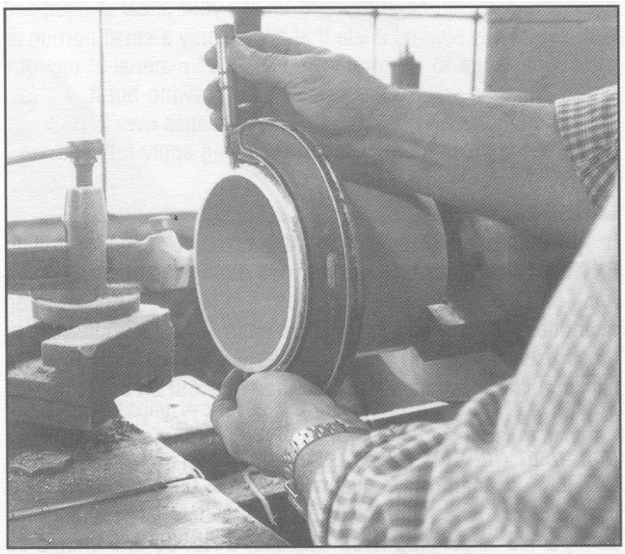


A stationary router is particularly useful for cutting keyways, slots and for performing other milling operations.

MACHINING

Turning

Most metalworking machine tools can be used in working with Exel Composites FRP shapes. Tool steel cutters – both single and multiple points – are entirely satisfactory for short run machining operations on small quantities of Exel Composites material. Carbide tool bits such as Carboloy 999 or Wiley's E-3 are recommended whenever a great deal of machining is to be done.



When turning fiberglass on a lathe, set the cutter slightly above center to reduce tearing action on the glass fibers.

In general, dimensional tolerances should match cold rolled steel tolerances; feeds and speeds should match those used for brass or aluminium.

The best machined finish can be obtained by climb-cutting instead of under-cutting. Reason: climb-cutting reduces tearing action on the glass fibres. A water coolant will also aid in giving a good machined finish.

Round nose lathe tools provide good finishes; the tool should have very little clearance. A single point tool tends to tear the material and also results in round corners rather than sharp corners. Surface speeds should be adjusted to give the desired finish and will be dependent on the hardness of the material and the type of cutting tool in use. The work should be fed continuously and steadily,

for if the tool is stopped in the middle of a pass, the material will be noticeably marked.

Threading and Tapping

Threading of FRP reinforced material is not recommended as a means of mechanical fastening when high strength is required, and should be avoided in the design of fabricated components whenever possible. The threading operation cuts the continuity of the glass fibres and leaves only the sheer strength of the resin component to provide the strength of the thread.

Threaded connections are satisfactory where strength is not an important consideration.

Bonding of the threaded connection with a polyester or epoxy adhesive will improve the strength of the connection.

Standard taps and dies can be used for threading Exel Composites shapes with plain or soapy water as the cutting lubricant. If the joint is to be later bonded with adhesives, then only plain water should be used.

When tapping a blind hole, be sure to allow adequate clearance at the bottom of the hole to prevent the tap from bottoming and damaging the threads.

Grinding

Grinding is generally not recommended on Exel Composite shapes. Centreless grinding of tubes and rods can be done satisfactorily if this specialised equipment is available. In ordinary grinding operations the dust tends to load the stone and stop the grinding action. If grinding is required, use a coarse grit wheel and water as coolant.

Sanding

Open grit (40 to 80) sandpaper on a high speed sanding wheel gives best results. Use very light pressure – do not force the sander against the FRP surface because heavy pressure may heat up and soften the resin. Wet, fin grit sandpaper applied by hand or with an orbital sander will produce a high gloss finish.