PIGS IS PIGS

Episode 4

Our story thus far: Not only did Mr. Morehouse balk at paying Mike Flannery (agent for the Interurban Express Company) livestock charges for two guinea pigs ordered for his son, claiming they should be billed at the lower rate for pets rather than the higher for livestock, he also refused to pick up the tab for the cabbages Flannery bought to feed them. Moreover, the volume of paperwork between Flannery and the home office, and the latter's interoffice memos concerning the matter took an inordinate amount of time to complete, and the original two guinea pigs and their descendants now numbered an even 800! Not only was Flannery running out of room to house the animals he was very low on cash having spent $64 for cabbages to feed them. In the meantime and in their infinite wisdom, the home office had reclassified the guinea pigs as "pets" and instructed Flannery to deliver them to morehouse and collect the appropriate charges. Our story concludes.

Flannery was crowded into a few feet at the extreme front of the office. The pigs had all the rest of the room and two boys were employed constantly attending to them.

The day after Flannery had counted the guinea-pigs there were eight more added to his drove, and by the time the Audit Department gave him authority to collect for eight hundred Flannery had given up all attempts to attend to the receipt or the delivery of goods. He was hastily building galleries around the express office, tier above tier. He had four thousand and sixty-four guinea-pigs to care for! More were arriving daily.

Immediately following its authorization the Audit Department sent another letter, but Flannery was too busy to open it. They wrote another and then they telegraphed:"Error in guinea-pig bill. Collect for two guinea-pigs, fifty cents. Deliver all to consignee."

Flannery read the telegram and cheered up. He wrote out a bill as rapidly as his pencil could travel over paper and ran all the way to the Morehouse home. At the gate he stopped suddenly. A sign on the porch said, "To Let." Mr. Morehouse had moved!

Flannery made feverish inquiries in the village. Mr. Morehouse had not only moved, but he had left West-cote. Flannery returned to the express office and found that two hundred and six guinea-pigs had entered the world since he left it. He wrote a telegram to the Audit Department.

"Can't collect fifty cents for two guinea pigs. Consignee has left town, address unkown. What shall I do? Flannery."

The telegram was handed to one of the clerks in the Audit Department, and as he read it he laughed. "Flannery must be crazy. He ought to know that the thing to do is to return the consignment here," said the clerk. He telegraphed Flannery to send the pigs to the main office of the company at Franklin.

When Flannery received the telegram he set to work. The six boys he had engaged to help him also set to work. They worked with the haste of desperate men, making cages out of soap boxes, cracker boxes, and all kinds of boxes, and as fast as the cages were completed they filled them with guinea-pigs and expressed them to Franklin. Day after day the cages of grunea-pigs flowed in a steady stream from Westcote to Franklin, and still Flannery and his six helpers ripped and nailed and packed—relentlessly and feverishly. At the end of the week they had shipped two hundred and eighty eases of guinea-pigs, and there were in the express office seven hundred and four more pigs than when they began packing them.

"Stop sending pigs. Warehouse full," came a telegram to Flannery. He stopped packing only long enough to wire back, "Can't stop," and kept on sending them. On the next train up from Franklin came one of the company's inspectors. He had instructions to stop the stream of guinea-pigs at all hazards. As his train drew up at Westcote station he saw a cattle car standing on the express company's siding. When he reached the express office he saw the express wagon backed up to the door. Six boys were carrying bushel baskets full of guinea-pigs from the office and dumping them into the wagon. Inside the room Flannery, with his coat and vest off; was shoveling guinea-pigs into bushel baskets with a coal scoop. He was winding up the grunea-pig episode.

He looked up at the inspector with a snort of anger.

"Wan wagonload more an' I'll be quit of thim, an' niver will ye catch Flannery wid no more Guinea-pigs on his hands. No, sur! They near was the death o' me. Nixt toime I'll know that pigs of whativer nationality is domistic pets— an' go at the lowest rate."

He began shoveling again rapidly, speaking quickly between breaths. "Rules may be rules, but you can't fool Mike Flannery twice wid the same thrick—whin ut comes to live stock, clang the rules. So long as Flannery runs this expriss office—pigs is pets—an' cows is pets—an' horses is pets—an' lions an' tigers an' Rocky Mountain goats is pets—an' the rate on thim is twinty-foive cints."

He paused long enough to let one of the boys put an empty basket in the place of the one he had just filled. There were only a few guinea-pigs left. As he noted their limited number his natural habit of looking on the bright side returned.

"Well, annyhow," he said cheerfully, " 'tis not so bad as ut might be. What if thim pigs had been elephants!"

THE END

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NUMBER 4

THE M.C. GILL DOORWAY

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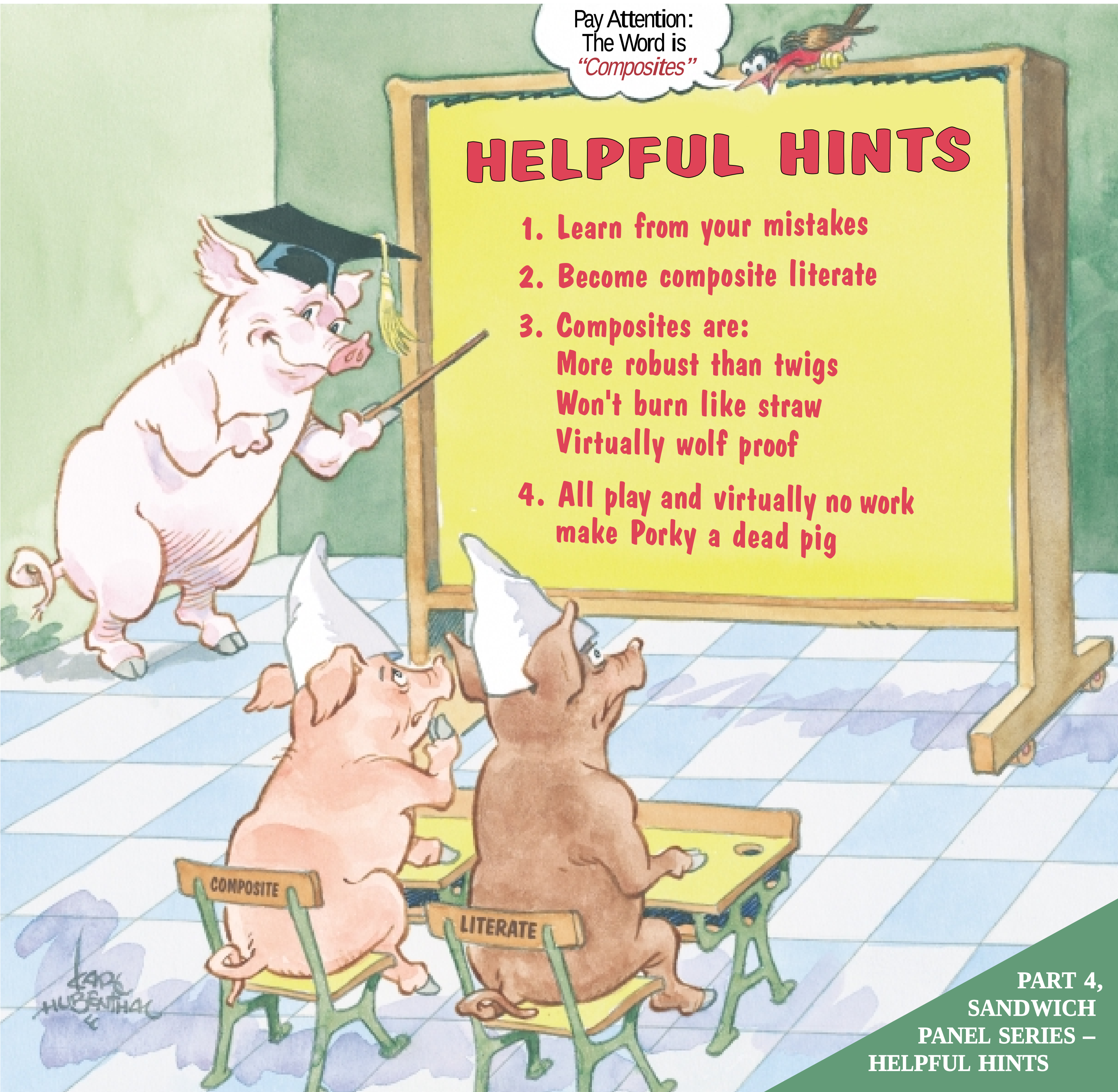
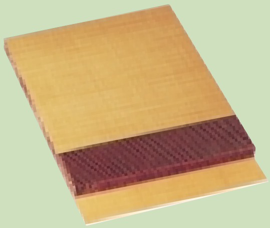
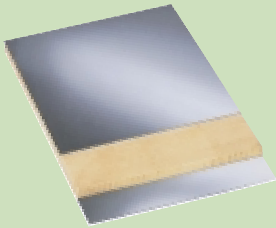
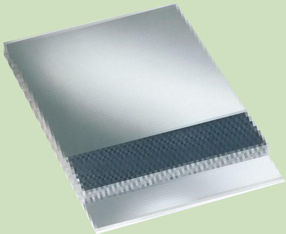


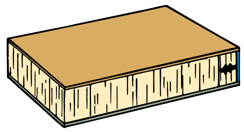
PART 4, SANDWICH PANEL SERIES – HELPFUL HINTS

Helpful Hints on Sandwich Panels

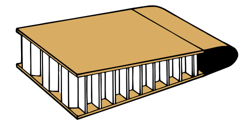
A REVIEW, PART 4 This issue of the M. C. Gill Doorway is the final issue in our Sandwich Panel Review series. Part 1 dealt with a general overview of sandwich panels and their components; Part 2 covered the same subject matter but in much greater depth; and Part 3 explored some of the preliminary design calculations necessary for designing panel constructions to meet specific applications. Part 4 brings together updated Helpful Hints articles that have appeared in past Doorways. Our readers have told us that the Helpful Hints are very useful reference materials, and having them incorporated into one issue should make them doubly helpful. If you did not receive any or all of the previous issues of this series, please contact our Marketing Services Department and we will be pleased to send them to you.





Edge Closure Designs



A major design consideration for raw stock sandwich panels is closing out the edges. Exposed edges are a weakness in the design because the light weight core is easily susceptible to damage from the environment. Proper edge closure protects both the adhesive and the core itself. Balsa wood, Nomex® and paper honeycomb are core materials most susceptible to environmental damage. Properly designed edge closure is essential in optimizing the end use, but with the various alternatives available selecting the proper method often presents the design engineer with a dilemma.

Purpose of Edge Closeouts

Edge closure can serve the following purposes:

1. Seal the panel from weather, moisture and contaminants;
2. Improve appearance;
3. Improve mechanical strength and stability of panel;
4. Provide solid attachment points for fastening or joining; and,
5. Serve special purposes or create shapes for a given application.

The type of edge close-out depends on the purpose or end use. Table 1 (below) summarizes the most common design considerations.

Application Methods

Sealers, like paint, are applied by brush.

Epoxy potting compounds are usually applied with a spatula or trowel. The core is removed around the edge and the grout is then applied.

Tapered close-outs are part of the manufacturing process and must be executed while the panel is being produced. The core is either machined to shape or slightly compressed.

Structural shapes can be bonded in place during the manufacturing process or as a secondary operation after the panel is made, although this generally provides lower structural strengths. The thickness of the edge closure must not exceed the overall panel thickness by more than .015". Core tolerances are generally ± .010" so thickness is critical when bonding edge extrusions inside the panel facings.

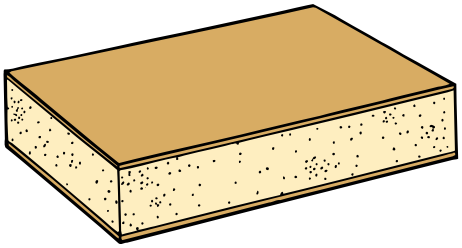
Various types of edge closures are illustrated on Pages 4 and 5.

TABLE 1—CONSIDERATIONS FOR EDGE CLOSURE

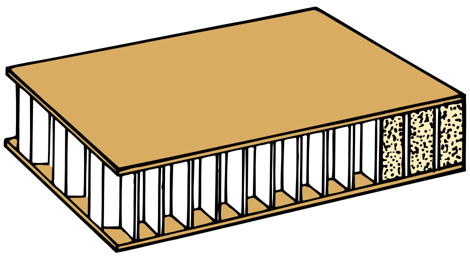
Edge Close Out	General Comments	Cost Factor	During or After Panel Assembly	Weight	Structural Capacity	Environmental Moisture Protection	Problems Due To Thickness Tolerance	Typical Applications
Sealed Edge (epoxy) (1`)	A two-part epoxy can seal solid cores like balsa wood and foam.	Very Low	After	Very Light	None	Fair	None	Solid core panels in interior applications.
Potted Edge (2)	Usually a 45 pcf epoxy grout to seal honeycomb panels.	Low	After	Medium	Minimal	Good	None	Weather proof applications, neither structural nor decorative.
Solid Edge (3)	High density foam, plywood or hardwood, e.g., spruce.	Low	Foam-During; Wood-After	Medium	Foam-Fair; Wood-Good	Foam-Good Wood must be sealed	Critical	Low cost with good mechanical strength. Wood for interior application only. "End grain" wood superior to flat grain. Good for doors.
Formed Facings (5,6,7,8 13,14,15)	Many design variations; either frp or metal facings will work.	Medium	Before	Light	Low-Fair	Metal-Good Frp-Excellent	Average	Interior decorative panels. Weather sealed panels.
Snap-on Moldings (4,16)	Plastic or metal; good in decorative applications. May want to seal with adhesive.	Medium	After	Light	None	Fair	Less than average	Easy to do at customer's shop after cutting to size. Often used in galley panel applications. Core should be sealed.
Sheet Metal (10)	Many variations; can be mechanically fastened or bonded.	Medium	Either	Light-Medium	Fair	Fair to Excellent	Average	High volume jobs, especially commercial grade.
Standard Extrusions (4,9,11,12)	Limited number of thicknesses available.	High	Either	Varies-Usually Heavy	Excellent	Excellent	Critical	Structural applications. If bonded during panel assembly, it may cause warp problems.
Special Extrusions (5,6,7,8,10, 13,14,15)	Often best choice for high volume structural parts	Very High	Usually During	Heavy	Excellent	Excellent	Critical	Structural. Cargo pallets and places where fastening to panel is a problem.
Compressed or Machined Core (7)	Core is slightly compressed or machined to tapered close-out.	Medium-High	Before	Light	Good	Good	Critical	To fit into custom designs. Helicopter panels.

NOTE: Numbers in ( ) in "Edge Close Out" column correspond to illustration numbers on pages 4 and 5.

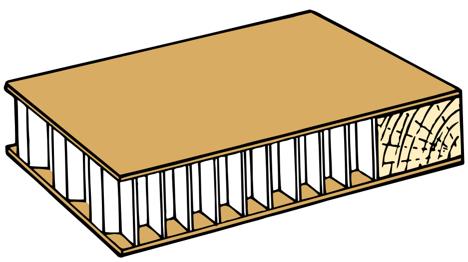
Edge Closure Designs



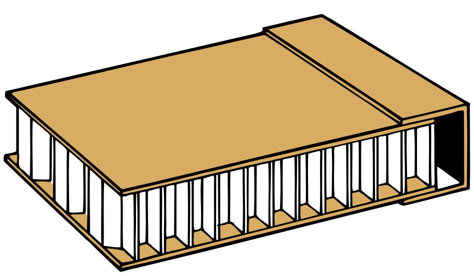
1. A solid core can be sealed with special epoxy paint sealers.



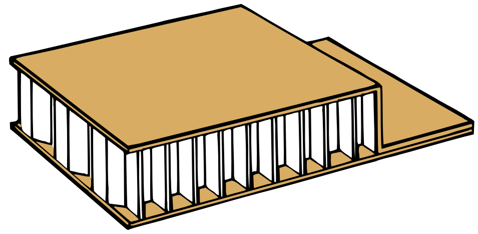
2. For a potted edge the core is removed, then potting compound is inserted with a trowel.



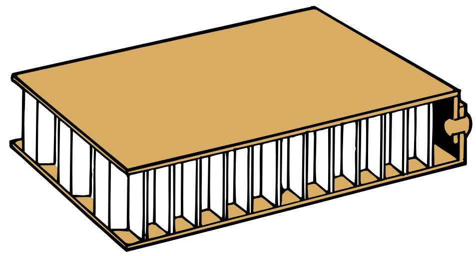
3. Solid edge. High density foam, hardwood or metal is bonded in place during or after panel is made.



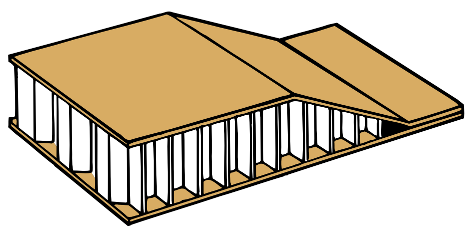
4. Formed metal or plastic is snapped on and/or bonded after panel is made. It can be tapered for tight fit.



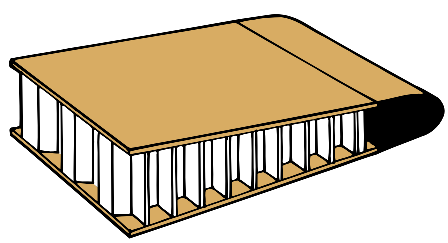
5. Formed facings. One skin is formed to fit over the edge, then bonded to other facing during panel assembly.



6. Formed facings. Skin have to be formed prior to panel assembly. Can be bonded or riveted together.

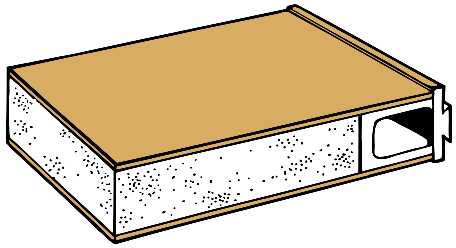


7. Tapered core requires close tolerance work in bonding operation. Core is machined to taper.

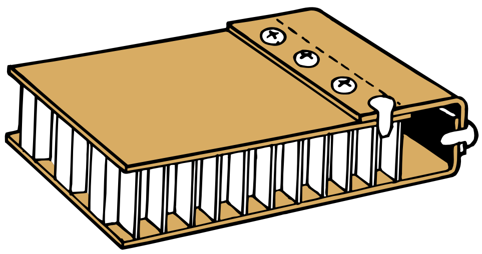


8. Special shaped extrusion for aerodynamic or other purpose is bonded in place.

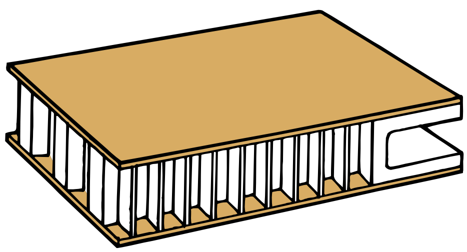
Edge Closure Designs



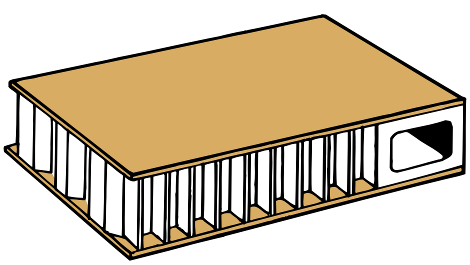
9. Special extrusion is designed to facilitate later fastening operations in structural strength applications.



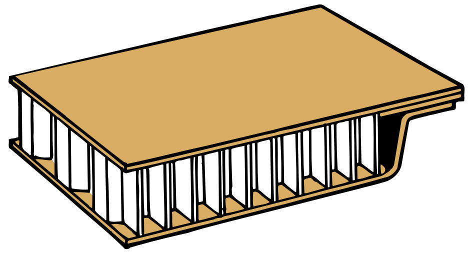
10. Sheet metal is mechanically fastened, or bonded, after panel is made.



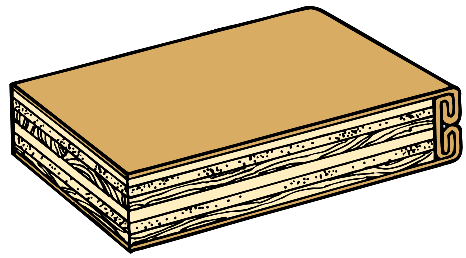
11. Structural shape is bonded into panel during or after panel assembly.



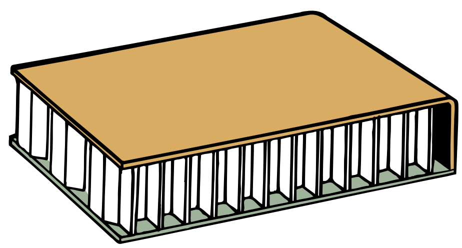
12. Structural shape is bonded into panel, sealing edge and providing mechanical strength.



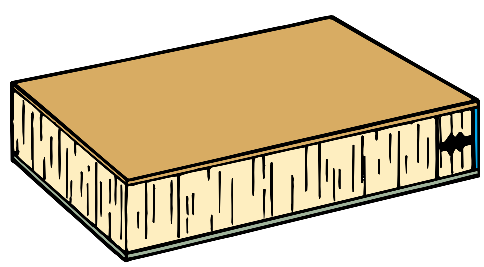
13. Zee-type edge is bonded in place after panel is made.



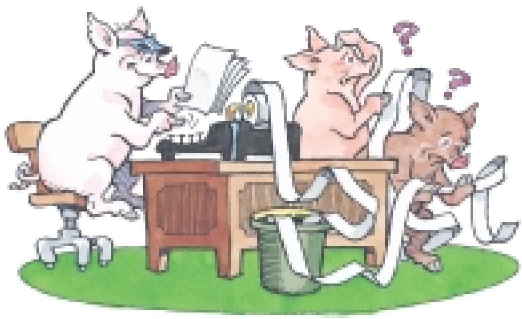
14. Plywood core with metal facings turned over and lock seamed to channel insert.



15. Formed facings. One skin is formed to fit over the edge.



16. Slot in core is routed, then T extrusion is bonded in place.



Calculating Weights

The M. C. Gill Corp. has constructed a simple nomograph to enable a quick calculation of the weight of a given sandwich panel configuration. For accuracy, you must know the following:

1. The panel thickness and type and thickness of the facings, in inches.

2. Density of core, lbs/cubic foot (ft^3).

3. Weight of adhesive, lbs/square foot (ft^2). The answer is read on the red horizontal line in the center of the nomograph in lbs/ft^2. To convert to kg/m^2 multiply: lbs/ft^2 x 4.93.

The use of the nomograph is best illustrated by a sample problem.

Find the weight per sq. ft. of a sandwich panel .532" overall thickness with 1/4" cell, and .004" thick foil aluminum honeycomb core with.020" top face and .012" bottom aluminum face.

Preliminary figures:

Total skin thickness: .020" + .012" = .032"
Core thickness: .532"–.032" = .500"
Core density: From Table 2 the density for 1/4" cell –.004" foil aluminum honeycomb is 8.1 lbs/ft^3.

Enter skin thickness vs. weight chart at .032" on the skin thickness ordinate and follow that line horizontally until it intersects with the line for aluminum, go vertically down to the bottom of the graph and stop at the skin weight, .45 lb/ft^2.

Next, enter core thickness vs. core weight chart at .5" core thickness and go horizontally until intersection with the 8.1 lbs/ft^3 density line. Go vertically up to the top of the graph and stop at the core weight, .32 lb/ft^2.

Draw a line connecting the skin weight and core weight. The point at which this line intersects the total panel weight line is the answer, in this case .86 lb/ft^2.

Adhesive Weight: The nomograph is based on a standard adhesive weight of 0.06 lb/ft^2/face (0.12 lb/ft^2 of panel). If the adhesive weight is known to differ from this figure, a correction should be made. Typical total adhesive weights are given below.

Adhesive Weight (lbs/ft^2 of panel)

0.12 for honeycomb core—all skins

0.09 for end grain balsa wood core and metal skins

0.06 for foam core—all skins

0.15 for balsa core and fiberglass skins

For convenience some of the common types of sandwich cores and their densities are presented in Table 2.

TABLE 2
Core Density by Type
(lbs/ft^2)

Density	Core Type
1.6	1/4" cell, .0007" foil, alum. honeycomb
2.0	polystyrene and 2 lb. polyurethane foams
2.3	1/4" cell, .001" foil, alum. h.c.
3.1	3/16" cell, .001" foil, alum. h.c.
4.0	4 lb. polyurethane foam
4.3	1/4" cell, .002" foil, alum. h.c.
4.5	1/4" cell, glass/phenolic h.c.
4.5	1/8" cell, .001," alum. h.c.
5.0	1/8" cell, Nomex® h.c.
5.7	3/16" cell, .002" foil, alum. h.c.
7.9	1/4" cell, .004" foil, alum. h.c.
8.1	1/8" cell, .002" foil, alum. h.c.
9.5	balsa wood, aircraft grade
40	plywood

Many other types of cores have their density called out in their name, i.e., 5 lbs./ft,^{3} 1/4" cell honeycomb. Because the density is given these types were not listed here.

The Nomograph Is Based On The Following Formula:

$$W_p = K_s t_s + \frac{t_c d_c}{12} + W_a$$

where:

W_p = weight of panel, lbs/ft^2
t_s = total thickness of skins, in.
t_c = thickness of core, in.
d_c = density of core, lbs/ft^3
W_a = total weight of adhesive, lbs/ft^2

K_s = multiplying constant:

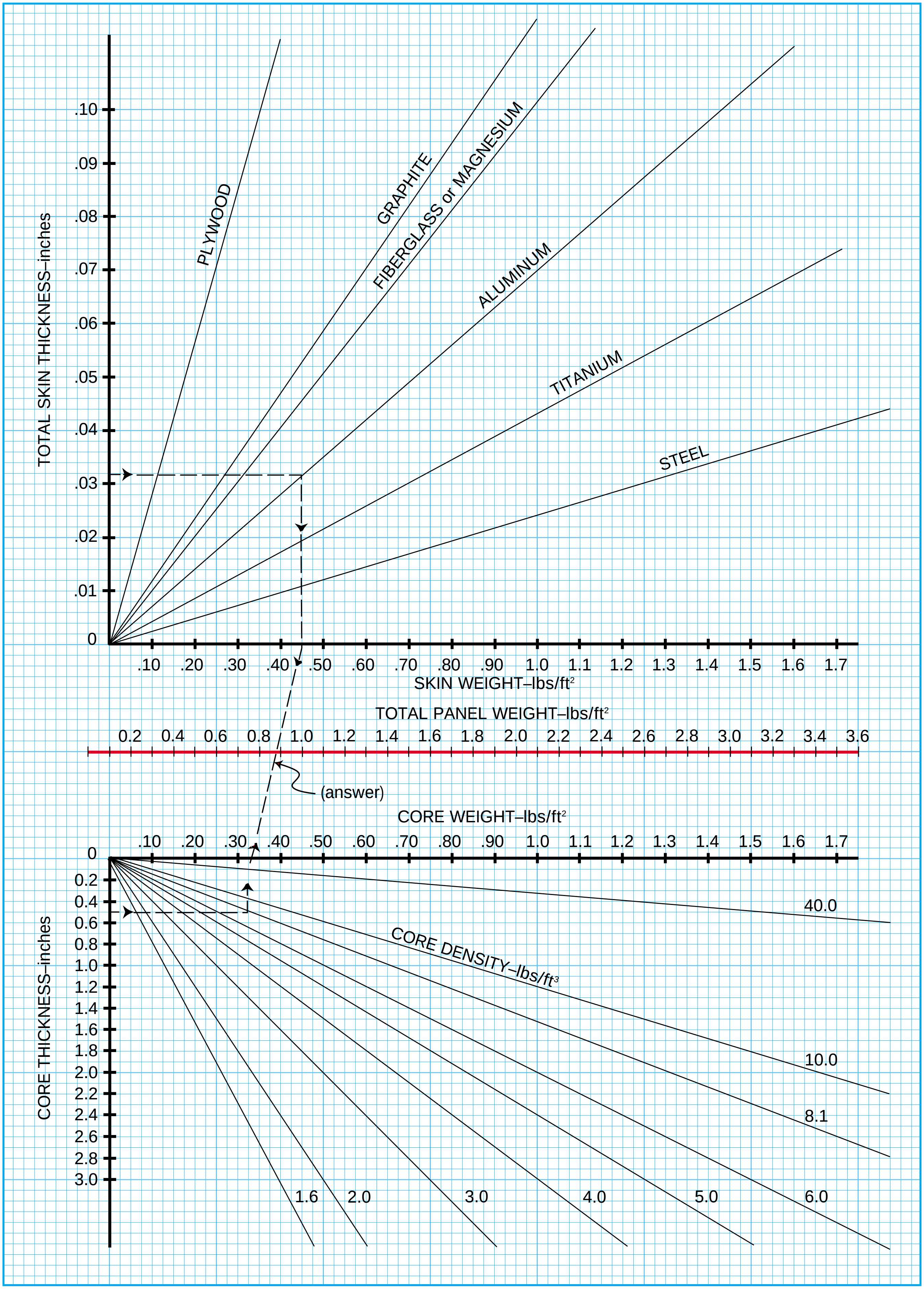
8.00 for graphite skins

10.00 for fiberglass skins

14.06 for aluminum skins

41.50 for steel skins

0.33 for wood skins


TOTAL SKIN THICKNESS–inches
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
0
PLYWOOD
GRAPHITE
FIBERGLASS or MAGNESIUM
ALUMINUM
TITANIUM
STEEL
.10 .20 .30 .40 .50 .60 .70 .80 .90 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7
SKIN WEIGHT–lbs/ft²
TOTAL PANEL WEIGHT–lbs/ft²
0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6
(answer)
CORE WEIGHT–lbs/ft²
.10 .20 .30 .40 .50 .60 .70 .80 .90 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7
CORE THICKNESS–inches
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
CORE DENSITY–lbs/ft³
40.0
10.0
8.1
6.0
1.6 2.0 3.0 4.0 5.0 6.0

Cutting

When cutting any sandwich panel especially one with unidirectional facings and/or aluminum honeycomb core, it is imperative to clamp the panel to a backing sheet to avoid delamination. This can be accomplished in one of three ways:

First, a backing sheet 1/4" to 1/2" thick of wood or particle board is required. The backing sheet should be clamped, not bonded, to the bottom facing of the panel to be cut, if the direction of the blade is moving top to bottom. If the blade is moving in a bottom to top direction, the backing sheet should be clamped to the top facing. Length of the backing sheet must be equal to the length of the cut, and width should extend at least two inches on either side of the cut. If a C-type clamp is used, the width of the backing sheet must extend over the saw table top so that the bottom of the clamps will clear the sides of the saw table. The clamps should be placed as close as possible to the cut and care should be taken not to dent or otherwise mar the top facing. The second method is to apply pressure only to the top facing so that the saw table acts as the backing sheet. A third would be to use a vacuum table. In most shops that perform an extensive amount of panel cutting this type of equipment is already in place, and can be done using a radial arm or table-top saw. Although not inexpensive, any facility where cutting panels is a daily routine is well advised to make the investment.

With Band Saws: We do not cut our standard products with band saws because the cut is slow and too difficult to control. Band saws can be used for making rough cuts to loose tolerances.

A fence should be used to control the cut as much as possible. Most M.C. Gill products may be cut with a standard 8-10 teeth/inch band saw. It will dull rapidly; but, even when dull, it gives a fair cut and is inexpensive to replace. We have cut sandwich panels that have stainless steel or titanium skins with a band saw because circular saws won't make this cut very well.

With Circular Saws: We use circular saws to do 98% of our finished product cutting. For worker comfort, safety and cleanliness, a good vacuum system to collect dust at the saw blade is a must. We normally use 12" to 16" diameter carbide tipped or diamond saw blades. Diamond blades are coated at 40 grit. Carbide blades, which have gullets between the teeth, are used for difficult-to-cut materials, such as metal faced sandwich panels or thick aluminum; diamond blades should not be used to cut aluminum. The more teeth per inch on a saw blade, the finer the cut. We use 12" blades with 60 to 72 teeth, alternating raker set. Recommended blade speeds are shown in the following tabulation. The performance of common type saw blades for difficult materials is given in Table 3.

Blade Diameter	Revolutions Per Minute	Surface Feet Per Minute
8	4,500	9,400
10	4,000	10,500
12	3,600	11,300
16	3,450	14,500

TABLE 3 – CUTTING M.C. GILL SANDWICH PANELS

Panel Construction	Blade Type	Comments
Fiberglass/wood	Carbide tip	Best, although dulling will occur. A grit blade will clog rapidly.
Fiberglass/balsa	Diamond grit Lasts longest. Carbide tip Carbide grit	Best, but will clog. Can be quickly cleaned with chemical stripper. Good, except it dulls rapidly. Satisfactory for small number of cuts.
Fiberglass skin/paper or Nomex honeycomb or foam	Diamond grit Carbide tip Carbide grit	Best. Possible. Make sure blade is sharp. Possible, some tendency to clog.
1) Alum. face/wood or foam 2) Alum. face/alum. honeycomb 3) Fiberglass/alum. honeycomb	Carbide tip only	All other blades are unsuitable.
Titanium or steel skins/any core	Band saw (Carbide tip) Carbide tip	Cuts with difficulty and will make a rough cut. Should buy panels finished to size Dulls rapidly, not recommended.
Unidirectional glass or graphite*/any core	Diamond grit	Best. Others may delaminate the fibers.
Kevlar/Nomex (over 25% resin content)	Diamond grit Carbide tip	Best, although will leave slight fraying at cut edges. Possible.
Reminder: Make sure any blade is reasonably sharp. Even the recommended blades require periodic sharpening to obtain satisfactory cuts.		
Our standard saws are:	14" diamond grit	Standard slot, 4 reliefs.
	12" carbide tip	60-72 teeth.

**Because graphite dust will short out electric motors, a vacuum system should be used to collect the dust at the point of the cut.*

Routing

When routing panels with very soft skins (such as 3003H14 aluminum) the aluminum will tend to gall on the bit, greatly shortening the bit life. Care must be taken to keep the bit clean.

Diamond grit router bits are not recommended, except for special applications. They are relatively expensive and must be cleaned frequently. They can, however, be re-coated with diamond grit when they wear out. Recoating costs approximately 80% of the cost of a new blade.
A special carbide router bit, resembling a round file, is used for most of our fiberglass routing, especially epoxy. Carbide bits are fairly inexpensive, and can be re-sharpened for approximately one-half the cost of a new bit.

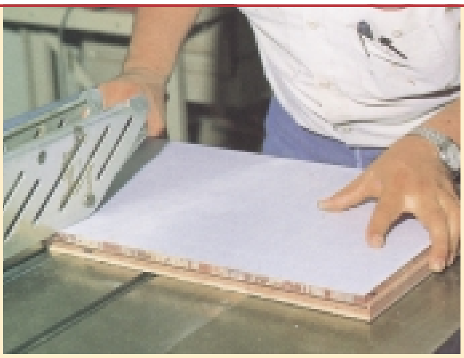
For most aluminum/balsa type panels, we recommend a 2-flute, spiral downcut, 1/4" high speed steel router bit because the cut is clean. These bits are very inexpensive and are thrown away when dull.

When selecting a router bit from Table 4, keep in mind that characteristics of the individual materials to be routed may influence the cutter selection. These factors include resin content, degree of cure and number of parts to be routed. Therefore, this table should be used as a guide only, and adjustment made for particular applications.

TABLE 4 – ROUTING M.C. GILL SANDWICH PANELS

We employ a router to make contoured cuts. The accuracy of the cut depends upon the accuracy of the tooling. Routing can be done to ±1/32" tolerances quite easily. We select our router bits according to the following chart.

Panel Construction	Type of Router Bit	Comments
Aluminum/wood	Solid carbide/spiral 2 flute	Best, dulls rapidly, can be sharpened.
Steel/wood	Carbide tip/spiral 2 flute High speed steel	Good, dulls rapidly. Not as expensive as solid carbide. Not recommended–dulls and may break.
Fiberglass/balsa	Special fiberglass Diamond grit Carbide tip	Best, inexpensive, can be sharpened. Best with rigid laminates. Will cut and clog, longest life, can be cleaned. Dulls rapidly, not recommended.
Aluminum/aluminum	2 flute–straight or spiral, H SS steel 2 flute–straight or spiral, carbide tipped	Good, least expensive, but dulls, can be sharpened. Best, longest life, but more expensive.
Fiberglass or graphite/paper or Nomex honeycomb	Diamond grit Carbide Carbide (Titanium coated)	Clogs, can be cleaned, smoother cut, more expensive. Best for graphite. Good, doesn't clog, less expensive. Best, least expensive.

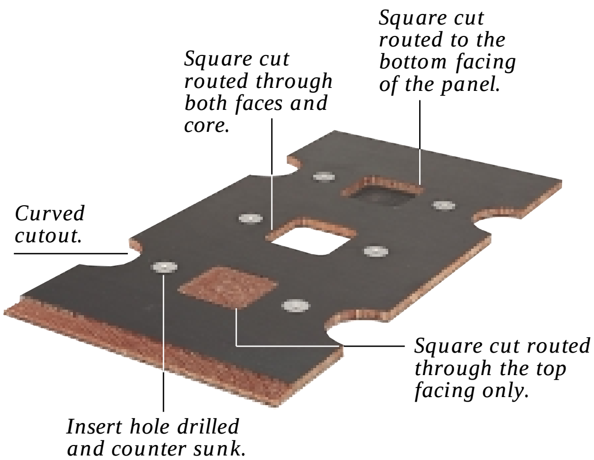


This panel is being cut on a table saw using a diamond grit blade with a backing piece (in this case, plywood) under the panel.

This panel is being cut on a table saw using a carbide tip blade with a backing piece (plywood) under the panel.

(Note: the blade guard on the saw has been raised for purposes of photographic clarity only. O.S.H.A. and standard safety procedures dictate this blade guard remain in a down position at all times when the saw is in use.)

SELECTED ROUTING PATTERNS



Drilling

For work requiring center-to-center hole tolerances of ±.030” or less, we recommend the use of a drill template with hardened steel drill bushings and a carbide shear bore drill bit. Good tooling will speed production and provide accuracy when repeating the hole pattern. For small jobs (less than 15 holes), a removable bushing (slip renewable) may be used. It is not as accurate as pressed bushings, but the tooling cost will be reduced.

For holes requiring close tolerance diameters (±.005” or less), a pilot hole should first be drilled through a bushing, then the hole counterbored with a carbide shear bore bit to the final diameter. Sandwich panels with soft cores (foam, honeycomb or balsa) should also be counterbored through the back skin–a pilot hole in soft cores will not hold the counterbore pilot steady. Use a drill press or a portable drill guide to simplify drilling holes 90° to the material surface.

For tooling and drill bushings drilled holes can be slightly larger than actually needed. A user may drill holes and install inserts of .250" into a replacement floor panel where only .216" is needed. This allows enough margin for the panel to line up with the hole pattern, and is usually acceptable when using “floating” inserts or when a mating part is not involved. To prevent delamination when drilling through sandwich panels, apply a steady pressure to the drill, allowing the bit to cut rather than forcing it through the material. Select the maximum rpm that doesn’t give spindle chatter, and use a particle board or wood backing piece where the drill exits the material.

Stack drilling is a good way to drill identical holes in several pieces, if they are firmly clamped together. However, center-to-center tolerance will usually suffer, especially on the last few pieces in the stack. When drilling deep holes lift the drill occasionally to clear away the chips to prevent galling and to produce a cleaner, fuzz-free hole.

Metal facings .032” and less generally require bits different from those used on thicker material. Drill points should be sharpened with smaller lip-relief angles to prevent drills from “hogging in” when penetrating the thin skin. Drills should have short flutes and heavy web construction. Consult a knowledgeable vendor before buying specific application bits.

Reaming holes in fiberglass is usually not necessary if the hole is drilled with a diamond hole saw. If it is necessary, use an expansion type, straight-flute carbide reamer with a back rake of 5° on the blades. For tapping holes in fiberglass, bond in tapped metal inserts with epoxy adhesive as tapped fiberglass is not particularly durable. If a laminate is to be tapped, use a fine thread tap and cut a chamfer around the hole to assure a sound first thread and avoid delamination. For blind holes allow room for clearance of 2-3 threads at the bottom of the hole to avoid the possibility of stripping the threads.

Selecting Drill Bits

Selection of the proper drill bit involves several factors, among them, size of the job, type of material, cost and drill life. The following considers the pros and cons of four of the most often used types of bits. If questions arise, the drill bit vendor should be contacted.

High Speed Steel

1. Lowest initial cost, readily available.
2. Short drill life, especially when drilling fiberglass about 500 holes between sharpening). This can be improved if a hard flash of chrome plating (.003"-.005") is put on the bit.

Tungsten Carbide

1. Higher initial cost but longer life. Can be resharpened.
2. In cutting fiberglass:
   a. Up to 3/16" diameter, grind drill bit to have a slight negative rake on the cutting tip.
   b. Over 3/16" diameter, use slow helix drill, ground to 55° point (sharp).
   c. For blind holes 3/16" and larger, use a fast helix bit ground to a 90° point.
   d. Recommended for large run production requirements only.

Diamond-grit Edged (hole saws)

1. For fiberglass only. Most expensive, but longest lasting, fastest and smoothest cutting. Recommended for high volume only. Forty grit recommended for most Gill products. Can be recoated at near initial cost.
2. Will drill a hole 3 times as fast as a carbide drill.
3. Dust collection system is mandatory.
4. Cannot be used with drill bushings or slip-renewables.

Solid Carbide Shear Bore

1. Fairly expensive, but very good for fiberglass.
2. Must be returned to manufacturer for sharpening.
3. Produces clean, fuzz-free holes in most facings without delamination.
4. Excellent for drilling clean, accurate holes in unidirectional S-2 glass,® and carbon-faced panels to .750" thick. Cuts quickly without tearing, delaminating or fuzzing the fibers around the hole.

For 90 percent of our non CNC work, we use general purpose high speed steel, jobbers length drill bits. For hand held drills we use jobbers length aircraft drill bits. There are special bits for “plastics,” but they are not designed for reinforced thermoset plastics. Finally, for stainless steel we use cobalt-steel drill bits.

Drill Speed

The speed of a drill bit is usually measured in surface feet per minute (sfm) and is calculated from the formula:

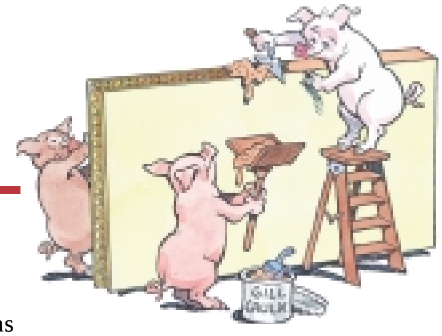
sfm = 0.26 X rpm X drill bit diameter (inches)

In general, the faster a drill bit turns, the fewer holes it can drill before sharpening; however, fast drill speeds allow a higher production rate. Consequently, on every job a drill speed has to be chosen that will allow a high rate of production without entailing excessive drill bit costs.

The following tabulation, excerpted from the Metal Cutting Tool Handbook, indicates recommended drill speeds for the more common types of facing materials used on M. C. Gill sandwich panels.

Material	sfm (surface feet per minute)	
	Carbide	High Speed Steel
Aluminum	150-550	200-300
Glass reinforced plastic	50-125	30-80
Graphite	50-125	30-80

Sealing



Many aircraft grade sandwich panel applications require that panel edges be sealed against moisture which would otherwise deteriorate the core and/or the adhesive bond line. Sealants and potting compounds are normally used, often as an added protection when structural shaped extrusions are used. The choice of sealant largely depends on the panel’s core material.

For Foam Core. A heavy latex paint or thin paste is acceptable and can be applied with a brush. Most sealants will work reasonably well with closed cell foams because they have low moisture absorption. The alternative is to rout back 1/4" around the perimeter and apply caulking compound with a spatula. This method is more time consuming and expensive, and the additional sealing obtained is marginal.

For Honeycomb Core. A potting compound is recommended. However, because it takes up considerable volume it must:

- Be light weight;
- Not become brittle, especially for panels in which the end use subjects it to considerable flexure;
- Adhere to the facings.
- Pass FAR 25.853 flammability requirements; and,
- Be easy to work with.

With regard to application, different aircraft maintenance operations have different priorities. Most prefer a one-part sealing system which avoids problems due to the short “pot life” of a two-part compound. No time or effort are required to mix catalysts. Cartridge guns for one-part systems can be used (although there are cartridge guns that will accommodate two-part compounds as well). Others (including the M.C. Gill Corp.) prefer to use a spatula to apply the heavy pastes required to seal honeycomb. If three to ten panels can be stacked and clamped together, a spatula application becomes even more desirable.

For Balsa Core. This core should always be sealed. A thin waterproof urethane paint coating is preferred for ease of application (it can be brushed on). A two-part thin epoxy will seal a little better but requires mixing for catalyzation and is therefore more time consuming. Heavier pastes are more difficult to apply properly and they are beneficial only if the core is routed out 1/4" around the perimeter. A spatula should be used with this type of sealant.

Note: There is a common misconception that if moisture comes into contact with an end grain balsa core, it will ultimately penetrate the entire core, rendering it useless. In fact, because the wood grain runs perpendicular to the facings, the end grain construction normally limits moisture penetration around a point in the balsa to no more than 1/2". However, the adhesive is critical in this situation because some adhesives absorb moisture which may cause bond failure to occur to some extent around the penetration point.

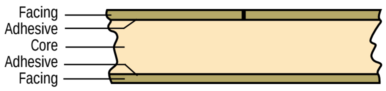
Splicing

Some people may be reluctant to buy or use spliced sandwich panels, believing that the splices inherently weaken the panel. While it is true that splices create another variable which has to be carefully controlled, the data in Table 5 clearly demonstrates that when spliced properly a sandwich panel suffers little or no loss in strength.

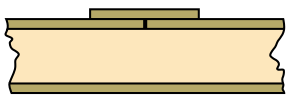
Size limitations of standard materials sometimes make it necessary to put a splice in a sandwich panel to make a large size. In this article we summarize our test data on sandwich panel splices, testing seven splicing techniques with the two most meaningful tests we know.

There are three types of splices that can be put into a sandwich panel—as shown in the following illustrations. Note: Doublers are not drawn to scale.

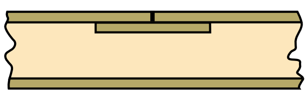
Splicing Skins



Butt splice of one skin, no doubler.

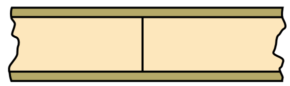


Butt splice, with doubler outside panel.
Doubler width: 3 times panel thickness.
Doubler thickness: same as face skin.

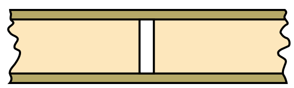


Butt splice, with doubler inside panel.
Doubler width and thickness: same as above.

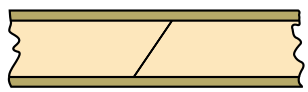
Splicing Core



Butt splice

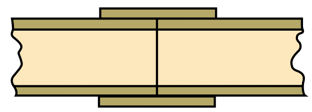


Poorly done butt splice, 1/4" gap in core (an example of poor worksmanship).

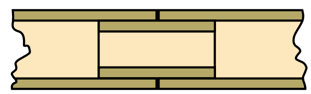


45º scarf splice, adhesive bonded.

Splicing Entire Sandwich Panel



Butt splice, overlapping doublers. Doubler width: 3 times panel thickness. Doubler thickness: 2 times face skin thickness.



U-splice with inlaid sandwich panel. Inlaid panel width: 3 times the thickness of the spliced panel. Inlaid panel thickness, d–2t where:
d=thickness of spliced panels;
t=average thickness of skins of spliced panels.

TEST METHODS

We felt two tests would adequately show the effect of a splice on the strength of a sandwich panel.

20" span flexure: With the splice located in the center of the span this test simulates the worst condition for load on the splice. This test measures how much the splice has affected the load bearing capability of the panel.

In-plane shear: With the splice located in the center of the panel. Many panels are loaded as shear panels, such as side walls of a tank. This test will detect any change in panel shear strength.

CONCLUSION: The splicing creates another variable which must be closely controlled, but if properly done the mechanical strengths will not be significantly lowered.

TABLE 5 – MECHANICAL TESTS ON SPLICED SANDWICH PANELS

.375" thick sandwich panels made from .011" 2024T3 aluminum skins bonded to aluminum honeycomb, $^{1}/_{4}$" cell, 4.3 pcf density

	20" flex–2 pt. load		
	Ultimate load-lbs.	deflection @ 100# load-in.	20" rack shear-lbs.
No Splice			
Unspliced panel (control panel for comparison	210	.41	23,000
1. Splicing Skins			
1a. Butt splice skin, no doubler	91	failed	13,200
1b. Butt splice skin, doubler outside of panel	232	.40	22,000
1c. Butt splice skin, doubler inside panel (recommended procedure) doubler is t thick and 3d wide	254	.40	22,000
2. Splicing Core			
2a. Butt splice (our recommended procedure with no adhesive see page at the joint)	240	.39	22,000
2b. 45º scarf splice	220	.40	21,000
2c. Butt splice poorly done ($^{1}/_{4}$" gap)	172	.41	19,000
3. Splicing Entire Sandwich Panel			
3a. Butt splicing 2 panels, overlapping doublers doublers are 2t thick and 3d wide (recommended procedure)	237	.40	20,000
3b. U-splice with spline, inlaid panel panel is 3d wide	187	.40	20,000

NOTES: d = thickness of panels t = thickness of skins

Painting

Painting know-how is readily available but the following relates specifically to the coating of our panels and involves several factors.

1. The resin system and reinforcement used to construct the panel facing.
2. Surface preparation.
3. The actual painting.

Panel Facings Construction

M. C. Gill panels are basically ready to accept paint as produced. Our fiberglass panels typically have a faint characteristic surface texture of the woven cloth. Sometimes, there may be some shallow depressions which can often be tolerated, but may require filling and a very light sanding if a very smooth painted surface is required.

Resin System. The resin system greatly affects the success of subsequent painting.

a. Polyester (easiest to paint). Quality laminators produce panel facings with few if any voids; the extent of surface voids is a good indicator of the laminator's competency.

b. Epoxy (harder to paint due to the possibility of residual mold release on the surface). If we are advised when the order is placed that the panel facing(s) is to be painted, we will produce an epoxy surface free of residual mold release.

c. Phenolic or Polyimide (very difficult). Painting a surface constructed with either of these resins is not advised. If painting is absolutely necessary, the surface should be completely coated with filler and sanded smooth.

Reinforcement. Because most of our sandwich panel facings are reinforced with fiberglass and carbon, you should encounter few problems. Fiberglass and carbon facings can be very lightly sanded, but only enough to scratch the surface to improve paint adhesion. However, Kevlar® reinforced plastic is more difficult to paint and under no circumstances should it be sanded before painting due to Kevlar's tendency to "fuzz."

Surface Preparation

Proper preparation almost always boils down to four factors: sanding (or not sanding); the use of filler putty; use of solvent to clean the surface; and a primer coat prior to painting. Based on our experience the following guidelines generally apply:

a. Avoid sanding if at all possible. Direct roughing of the faces creates more problems than it solves. Any air voids just beneath the surface will be opened up by sanding. Worse yet is sanding into the glass fibers, as the exposed fibers can cause pinholes in the paint. Most hot pressed facings do not have a resin rich surface or gel coat and, as a result, the fibers are quite close to the surface. If sanding is necessary, we suggest very light sanding with a 240 grit paper.

b. The use of filler putty should be kept to an absolute minimum. Filling can be very time consuming, but, if surface

voids must be filled to avoid a pinhole surface, e.g., phenolic faces, filler putty must be used. Aircraft grade fillers are generally sprayable. Use a spatula to accomplish filling on the first try.

c. Wiping the surface with a solvent is not recommended. It is almost impossible to wipe off the thin film of solvent before it evaporates, in which case the contaminants are spread around. Wiping with a rag dampened with plain water and very mild detergent, followed by another water wipe, gives better results. If a solvent wipe is mandatory, use MEK solvent applied with a clean cotton cloth and a second wipe with a dry rag before the solvent dries (change rags frequently if the surface is large). Always wear rubber gloves and work in properly ventilated areas when using MEK.

d. Priming should be done if the paint manufacturer recommends it. Primers can improve adhesion, though for many interior applications paint directly applied to the facing is adequate. Polyurethanes and epoxies are costly paints but are proven coatings and superior adhesion justifies the expense.

Paint Application

Spraying is the most common method of application. Use the pressure and nozzle system recommended by the paint manufacturer. Dust must be kept to a minimum; use a tack rag just prior to painting and paint in a dust-free environment. Final film thickness of 1.2 to 2 mils is usually recommended; coverage should be about 300 to 400 sq. ft. per gallon. Two thin coats give better results than one thick coat. Apply the first coat then a second before the first coat is totally dry to assure good bonding between the two coats. Minor filling of the first coat can be done but it must be dry enough so that the filler will spread.

Another Alternative – Overlays

Because voids in the surface always result in paint pinholes that require extensive rework, customers sometimes prefer an overlay. Tedlar® (polyvinyl fluoride film) is a lightweight overlay which we can bond directly onto the facing. Our patented Gillcoat system of fusing a colored resin system or pattern directly into the panel face during pressing provides a thicker and more abrasion resistant surface. It is also possible to bond on decorative overlays. Please advise us in advance when our panels are to be painted–we can suggest and recommend the most effective approach, in terms of appearance and expense. Having coated our products for more than 52 years, plus observing our customers' coating experiences, we believe we are knowledgeable in this rather limited field.

Avoiding Galvanic Corrosion

A perennial cause of premature failure of aircraft parts and components is galvanic, or electro-chemical, corrosion. The more noble of two metals in contact with an electrolyte, normally water, causes an electro-chemical attack on the less noble metal. Eventually the less noble material becomes so corroded it has to be replaced. However, with proper selection of materials and protective coatings, galvanic action can be either eliminated or greatly reduced.

All metals have a characteristic electric potential. When metals of different potential are in contact in the presence of an electrolyte (moisture, acid, etc.), a low energy current flows between the metals, resulting in the corrosion of the metal with the higher potential (least noble).

We have made a chart showing the relative potential for galvanic corrosion of a number of widely used metals. The more widely separated the metals are on the chart, the more likely corrosion will occur. For instance, 2024 aluminum will corrode in the presence of 410 stainless (active), but corrosion would be more severe in the presence of 410 stainless (passive). Metals in the same grouping normally do not cause galvanic corrosion on each other, i.e., titanium and stainless 304 (passive). If the cathode (most noble) metal is large compared to the anode (least noble) metal, the corrosion will be much more severe than if the sizes were reversed. For instance, bronze fittings can usually be used in steel water lines with only minor corrosion of the steel, but if steel fittings are used in a copper line they corrode rapidly.

Following are some general design guidelines to help avoid electro-chemical corrosion.

- Maintain constant stress, especially in fasteners. Irregular loading contributes to corrosion development.
- Separate or prime dissimilar metals with a dielectric material such as insulation or paint.
- Avoid combinations where the least noble metal is small, for example, a fastener should be slightly more noble (smaller potential) than the assembly it is holding.
- Utilize sacrificial corrosion, if necessary, by coupling parts to be protected to pieces of less noble metal which are not functional. The less noble metal then corrodes sacrificially.
- It should come as no surprise that the M. C. Gill Corp. encourages the use of fiberglass, which presents no corrosion problems even in the worst circumstances.

These corroded aluminum flooring panels were removed from the galley of a DC9. This amount of corrosion is typical for aluminum in "wet" areas.

CORRODING END
(Anode, least noble, +, high potential)

▲

1. Magnesium
   Magnesium alloys
2. Zinc
3. Aluminum A1100 (2S)
4. Aluminum 7075-T6
5. Cadmium
6. Aluminum 2024-T4 (17 ST)
7. Steel or Iron
   Cast Iron
8. Stainless 410 (active)
9. Ni-Resist cast iron
10. Type 304 stainless (active)
    Type 316 stainless (active)
11. Lead tin solders
    Lead, Tin
12. Nickel
    Inconnel (active)
    Hastelloy alloy C (active)
13. Brasses, Copper, Bronzes
    Copper Nickel alloy
    Monel nickel-copper alloy
14. Silver solder
15. Nickel (passive)
    Inconnel (passive)
16. Stainless 410 (passive)
    Titanium
    Stainless 304 (passive)
    Stainless 316 (passive)
    Hastelloy alloy C (passive)
17. Silver
18. Graphite, Gold, Platinum

▼

PROTECTED END
(cathode, most noble, —, low potential)

Repairing Skins

We believe that our customers seldom will have to repair delaminations on our panels, but we take this opportunity to pass on what we have learned.

Corner and Edge Delamination

Corner and edge delamination can usually be satisfactorily repaired to preserve the integrity of the panel, using a high quality room temperature curing adhesive. First, follow the adhesive application directions to the letter. Second, lay the panel flat with the delaminated skin on top and spread the adhesive uniformly on both surfaces to be bonded. Third, turn the panel over so that the delaminated skin is facing down and apply pressure evenly over the delaminated area using clamps or weights sufficient for intimate contact until the adhesive hardens. Be sure to protect the surface the panel rests on from adhesive seepage. Remember, a) thoroughly mix the adhesive in proper proportions, if mixing is required; b) evenly coat both bonding surfaces with the adhesive; and, c) maintain uniform pressure during the adhesive cure.

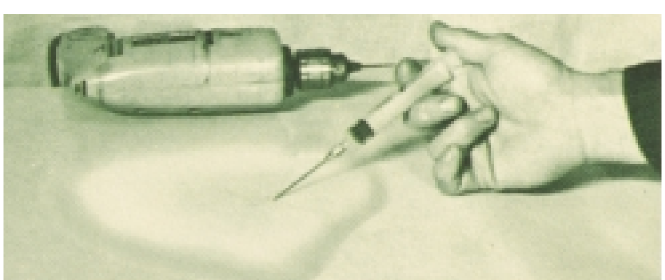
Do not move the panel until the adhesive has cured. Cure time can be observed empirically by feeling the adhesive that has squeezed out at the bond line or checking the excess adhesive left in the container used for application. Some epoxy adhesives do not develop full strength for a week at room temperature but can be handled after approximately 18 hours at 70°F

Blister Delamination

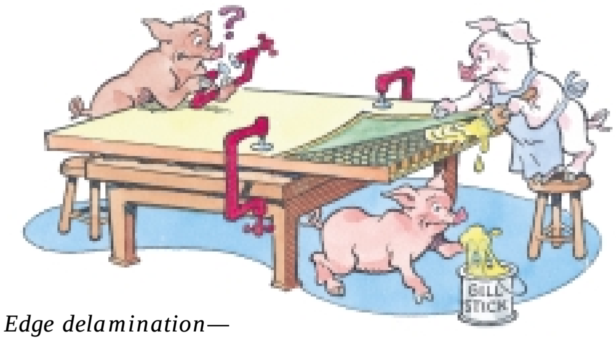
A blister in a sandwich panel facing can be repaired, but it could be an indication that the bonding of the entire panel is faulty. Exercise careful judgement in deciding whether to repair or replace structural panels.

Generally speaking, a blister in a solid core, e.g., end grain balsa wood, can be repaired by drilling one or more small holes, about 1/32," in the blistered skin and then injecting a thin adhesive into the blister through the holes with a syringe. Once the adhesive is in place, apply uniform pressure over the blistered area with clamps, weights, or vacuum bag until the adhesive has cured. Again, take precautions against adhesive seepage.

A blister in a honeycomb core sandwich panel presents more of a problem and syringe injection is not normally the solution.



Blister delamination—using a 10cc syringe, inject blister with thin epoxy adhesive. Apply pressure until adhesive cures.



*Edge delamination—
coat both skin and core with carefully mixed epoxy adhesive. Always apply pressure while adhesive cures.*

If the blister is close to a panel edge, it is better to peel back the skin from a comer until the blistered area is exposed and then repeat the procedure to repair corner and edge delamination described above.

If the blister is in the center of a honeycomb panel, the following alternatives are available.

1. Plug. Remove the skin around the blister with a hole cutter and cut a piece (plug) of the same facing material as close to the size of the area of exposed core as possible; apply adhesive to core and plug, place the plug in the cut-away section and apply pressure until adhesive cures. This type of repair is cosmetic and protects honeycomb cells from filling with liquids but does nothing for the load carrying ability of the panel.

2. Patch. Remove the skin around the blistered area cut a piece of the same facing material so that it covers the exposed core plus a minimum of two inches around all sides of the exposed area, i.e., a 2" diameter blister requires a 6" diameter patch. Apply adhesive to the patch and the entire area the patch covers (including the exposed core), and apply pressure until adhesive cures.

3. Plug and patch. Place a core plug over the blistered area as described in 1. above and immediately affix a patch over the plug (2. above), again making sure the size of the patch extends beyond the plug a minimum of 2" in all directions. Apply pressure evenly over the patch until the adhesive cures.

4. Replace facing. Peel off the entire skin and bond on a new one in the same manner as an edge delamination. This repair method probably should not be attempted unless adequate facilities are available to apply an even pressure over the entire new facing until the adhesive cures completely.

In the first three instances above, filling the honeycomb core with a filler such as epoxy resin may be advisable to maintain structural integrity. Where only a patch is used, filling the core to a point level with the top of the surrounding facing may be called for to avoid dimpling over the cut out area after the patch is in place and pressure applied.

Apropos for this issue of the Doorway is the work being done by the Commercial Aircraft Composite Repair Committee (CACRC). Since 1991, CACRC has been working toward standardizing composite repair, including a view to reducing those costs. For additional information please contact SAE's Becky Lemon at (412) 776-4841, Lufthansa's Carlos Blohm, 1997 Chairman at 49-40-507-02-612, or FedEx's Oksana Bardygula, 1997 Vice Chairperson at (310) 649-8526.