

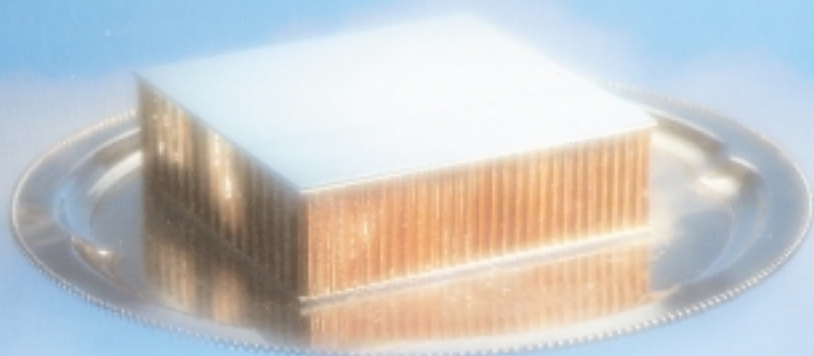
VOLUME 28  
SPRING 1991  
NUMBER 2



# THE M.C. GILL DOORWAY

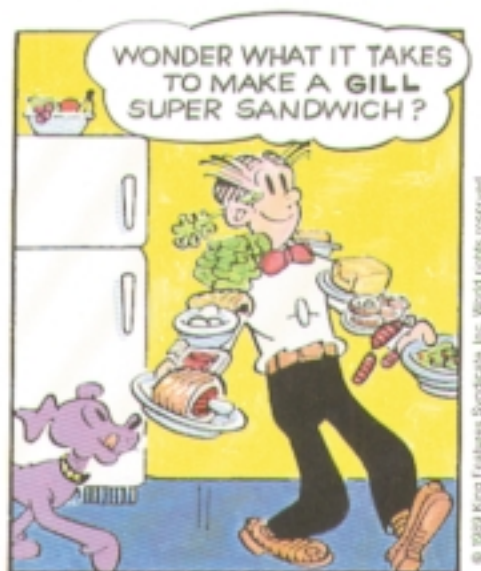
M. C. GILL CORP., 4056 EASY ST., EL MONTE, CA 91731 • PHONE 818-443-4022 • TELEX 67-7467 • FAX 818-350-5880

## SANDWICH PANEL REVIEW...PART 1



DAGWOOD, ARE YOU  
DREAMING ABOUT THAT  
SUPER SANDWICH AGAIN?





## Introduction

*In the Summer 1984, Fall 1984, and Winter 1985 issues of the Doorway, we published the first of our Home Study Courses. The subject matter was "sandwich panels" and it was very well received. We believe the time has come to update that series. We've moved up several notches on the sandwich panel learning curve in the past seven years and we wanted to share what we've learned with you. So, with this issue, we begin our Sandwich Panel Review.*

### The Making of a Sandwich Panel

For our purposes, a sandwich panel is a combination of thin, high strength facings on each side of a much thicker, light weight core material. There is a third component that is often overlooked, all important and poorly understood—a tough, but rigid adhesive attaching the facings to the core. All three components must be present to qualify as a successful sandwich panel.

As shown in the following illustration, the total thickness of the facing material(s) split in half and

RATIOS OF THICKNESS  
TO STRENGTH AND WEIGHT

	T	2T	4T
Relative rigidity	1.0	7.0	27.0
Relative flex strength	1.0	3.5	9.2
Relative weight	1.0	1.03	1.06



*Resistance to fire and toxic smoke is an advanced feature of Gill's graphite-phenolic/Nomex® honeycomb panel.*



*Resistance to repeated heavy loading, caster wheels and high heels provides the durability feature.*



*Extreme light weight and strength combine to afford energy savings in aircraft and other vehicles.*



separated by a core results in dramatic stiffness and strength improvements, with minimal weight increase.

This simple illustration also points out the value of making the sandwich panel as thick as possible. Since core materials are not only lighter than facings but also generally less costly **per unit of thickness**, a thicker panel with thinner faces will normally cost less and be more rigid. How thin they can be will be discussed in an upcoming issue of this Doorway series. Suffice for now to say, they have to be thick enough to withstand impact and attachment loadings.

All sandwich panels share certain advantages and drawbacks. They are all quite rigid and light in weight compared to alternative materials. On the minus side, sandwich panels sometimes must be sealed around their edges especially if a moist environment is anticipated; all are more costly than common comparable materials such as plywood or metal plate; honeycomb cells will hold moisture if a facing is punctured; attachments and inserts can be a problem; and one must bear loads with both faces.

### Evaluation Considerations

There are many other considerations than strength in evaluating sandwich panels, including:

**SAFETY**—Fire resistant; low toxicity and smoke emissions in a fire.

**WEIGHT**—Low initial weight; minimal weight gain when exposed to moisture, or when fastening systems and edge sealing are added.

**DURABILITY**—Corrosion resistant; resistant to repetitive loading, e.g., fatigue from flexural stresses, point loads such as high heels or caster

wheels, dent and puncture resistant; environmental resistance; no loss in strength from fabricating or from the addition of fasteners.

**COST**—Ease of fabrication from raw stock panel to "ready to install," e.g., simple installation of fasteners and rapid cutting with proper tools; inexpensive installation accessories such as inserts or other fasteners and edge sealant or close-out; high yield from raw stock panels, e.g., panel dimensions can be made compatible with finished sizes and resistant to edge damage during cutting using accepted cutting procedures.

### POOR EARL

*History tells us that the Earl of Sandwich invented the edible bearing his name and we have no reason to doubt that. However, we would be remiss if we did not point out that the good Earl had it entirely backwards when considering a load bearing sandwich panel. Whereas the tasty center portion is the key to a successful sandwich (the eating kind), the load bearing kind has a center that is either mostly full of air or woody tasting and the faces are tough and terribly chewy. The underlying principle of sandwich panel design is that the core, or the center part, serves primarily to hold the facings apart. The facings take the stress created when a load is placed on that panel and it is the facings which largely determine the sandwich panel's strength.*



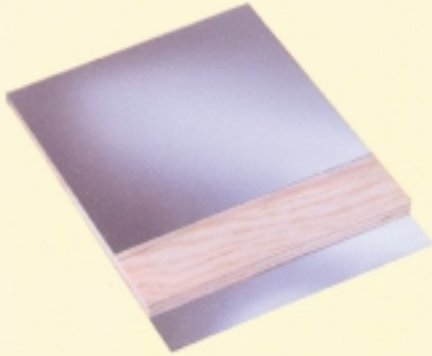
*The versatility of sandwich panels used for aircraft cabinetry is illustrated by the pictures above. From left to right, the sides, top and bottom of a food*

*service cart made by PTC Aerospace, the rear bulkhead in a Falcon Jet, a stowage unit also in a Falcon Jet, and a crew galley for the KC-10.*

## ***A Few of the More Common Configurations***

*Given the many different kinds of facing and core materials, the number of variations of different kinds of sandwich panels is almost endless.*

*The following considers the more common configurations and their advantages and disadvantages.*

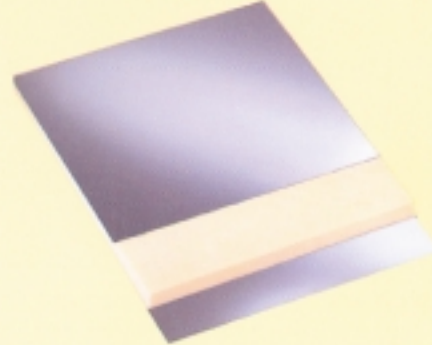


### **Metal Facings/Plywood Core**

Used in building construction and industrial applications, the metal (steel or aluminum) acts as a protective facing for the plywood core and greatly enhances the panel's strength.

*Pluses:* Low purchase price for core; high dent and puncture resistance; readily available; inserts usually not needed; and much greater rigidity than raw plywood.

*Minuses:* Heavy; untreated metal facings can corrode; not truly fire-resistant; and moisture absorbent.

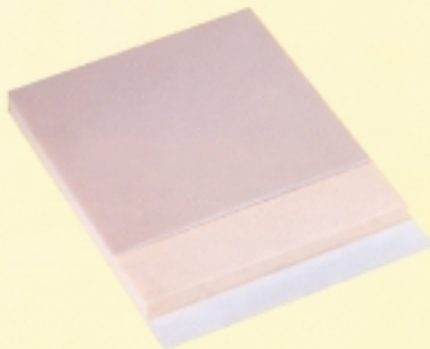


### **Metal Facings/Foam Core**

Used in non-structural applications utilizing its low cost and thermal insulation, such as refrigerated carts.

*Pluses:* Low initial purchase price; low weight; excellent thermal insulation; good point load resistance; good impact values.

*Minuses:* Aluminum facings are subject to corrosion (this can be corrected by anodizing them); delamination; low service temperature ranges; core is relatively brittle; high smoke evolution.

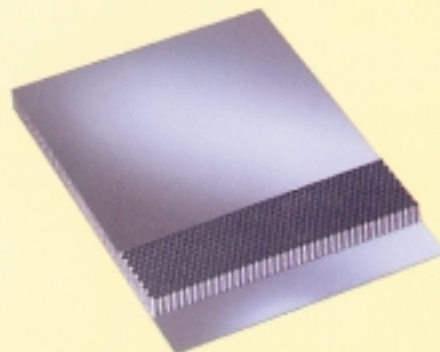


### **FRP Facings/Foam Core**

Foam core panels are widely used in commercial refrigeration construction, normally with galvanized steel facings.

*Pluses:* Low purchase cost for commodity type foams; very low panel weights; excellent thermal insulation; low moisture absorption; and solid core meaning good point load resistance; good corrosion resistance.

*Minuses:* Low resistance to repetitive flexure; delamination (facings separating from core) due to low core integrity; core has low tensile strength and is relatively brittle; and high smoke evolution in a fire.



### **Aluminum Facings/Aluminum Honeycomb Core**

A very common sandwich panel in the aircraft industry.

*Pluses:* Relatively low cost; high strength to weight ratio; excellent rigidity; and many combinations of different core configurations and facing thicknesses and alloys.

*Minuses:* Aluminum corrodes without proper treatment; is subject to denting and permanent distortion; aluminum honeycomb is more prone to point load failure; honeycomb cells may fill with liquid if facing is punctured; although non-burning and non-smoking, aluminum panels have poor burn-through characteristics and high heat contribution and conduction.

***Just how do you make a sandwich panel?***





## *Here's How M. C. Gill Makes Sandwich Panels*

### **Nomex Honeycomb Core Production**



This is where it begins. The aramid fiber paper (Nomex) feeds from the let-off reel into the printer oven.



One of two master control panels regulate paper humidity, the printing oven, emissions incinerator, paper feed conveyor, print roller and cutter.

### **Aluminum Honeycomb Core Production**



Very thin aluminum foil feeds from the let-off reel into a horizontal tank where it is sprayed and cleaned prior to alodining.



Foil from the horizontal tank feeds into the alodiner and oven, preparing it for printing of glue lines. Other steps for aluminum are the same as for Nomex honeycomb core, except that aluminum core does not go through the dipping process.

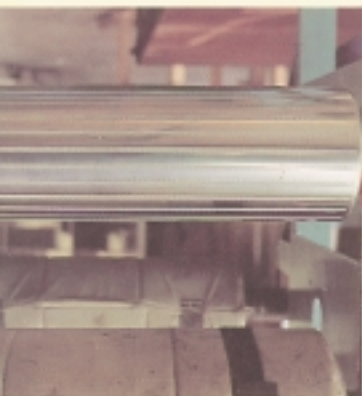
### **Adhesive Coating**



Our adhesive coating line produces only for internal Gill consumption. Many different proprietary formulations are used for bonding sandwich panel facings to both solid and honeycomb cores. Adhesives are so critical that we make them ourselves and they all meet the two common adhesive specs, MMM A 132, Type 1, Class 2 & 3, and MIL A 25463A. More important, they meet our own quality requirements.

The manufacture of sandwich panels is a specialized business with many variables to be considered. These include the integrity of the manufacturer, along with

experience, types of equipment and quality control procedures. Paramount in importance is that there be no surprises between the laminator and the customer.



A print roll applies glue lines to the Nomex paper. The glue is necessary for bonding the individual sheets together during the pressing process.



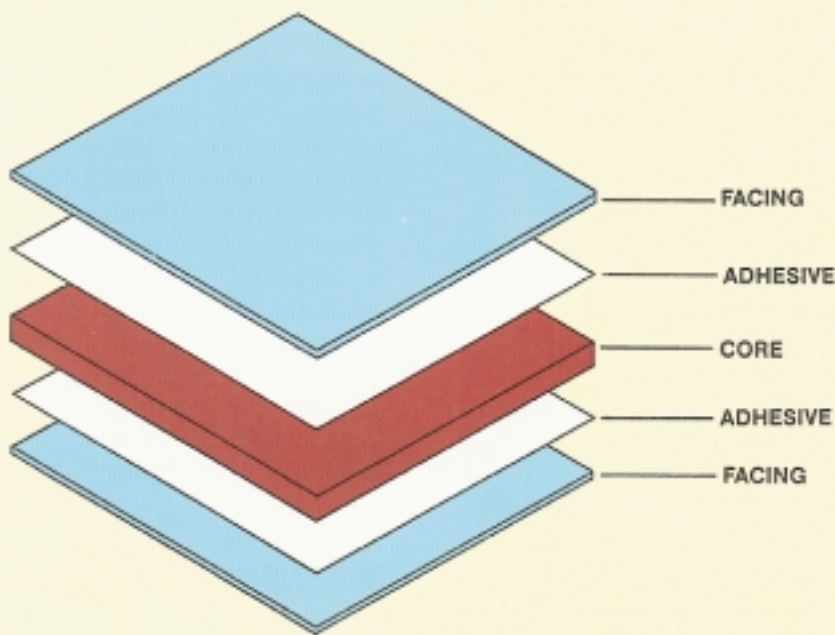
Printed Nomex paper comes out of the printer where it is sliced and stacked in piles of 100 sheets, preparatory for loading the press.



Stacking the individual sheets of printed Nomex paper, a critical step. Glue lines of one sheet cannot be placed directly over glue lines on the sheet below.



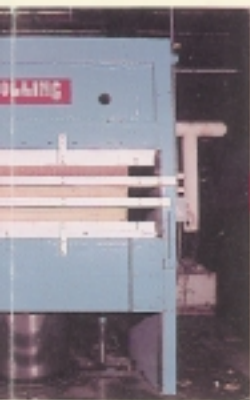
Stacks of printed Nomex paper under pressure to be pressed. A separate step, pin pressing, is required prior to the final pressing process.



The M.C. Gill Corp. uses sandwich panel facings of reinforced fiberglass and graphite (woven or unidirectional) and aluminum; adhesives of epoxy, contact, phenolic and polyester; and cores of foam, end grain balsa wood, and aluminum and aramid honeycombs. Aramid and aluminum honeycomb are available in a variety of cell sizes and densities ranging

from 1.8 pcf to 9 pcf. Stabilized compressive strength ranges from 55 psi to 1700 psi, with plate shear values between 100 psi and 500 psi. Aluminum honeycomb likewise is available in several cell sizes and densities from 1.6 pcf to 8.1 pcf and higher; with compressive strengths of 70 psi to 1100 psi. Plate shear strength values test from 60 psi to 670 psi.





Nomex paper are heated and the sheets together. In a few minutes the sheets are bonded to the core to expanding.



An individual stack is then placed on the expander where pin plies attach to the expander pins and then expand to the appropriate length.



Once expanded, the loaf moves to a dip room. After each dip, the loaf is placed in an oven. The number of dips and bakes is governed by the desired density of each finished loaf.

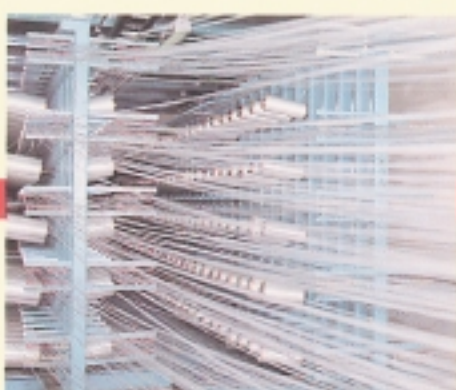


Finished Nomex loaves are ready for use. Large numbers on the loaves provide control with traceability. Small numbers provide similar information and inventory.

## Facings Production



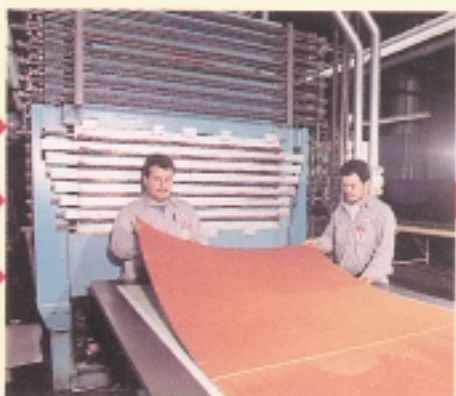
Technician prepares and tests viscosity of the cooked resin before it is placed in a holding drum and fed into the resin tray.



Glass rovings come off the spool creel just prior to dipping in the resin bath.



Rovings going through the dipping process, being fed onto the creel just prior to dipping in the resin bath.



The bottom facing has already been laid up. Honeycomb core slice is being placed on top of it.



Here, cross plies of the unidirectional facings are laid up on top of the honeycomb core.

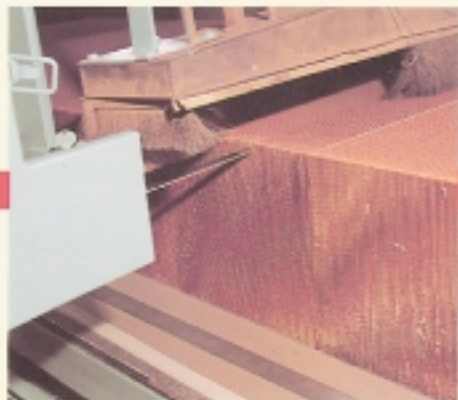


The laid-up panel goes into the curing oven, capable of handling seven panels at a time.





for slicing.  
ide Quality  
s provide  
ontrol.



A loaf is sliced by the computer controlled horizontal band saw. It cuts raw material up to 60" wide to virtually any thickness with a  $\pm .005"$  tolerance over the entire sheet.



The entire slice goes to a dial indicator table and thickness is measured along the entire length. Slices of the same thickness, density and cell size then await sandwich panel production. Each slice is tagged for traceability.



and being  
journey



M.C. Gill technician at one of the control panels, checking the oven's temperature.



The resin impregnated facing comes out of the B stage curing oven and is sliced to pre-determined length. It then goes into refrigerated storage to await sandwich panel construction.



ss, which is

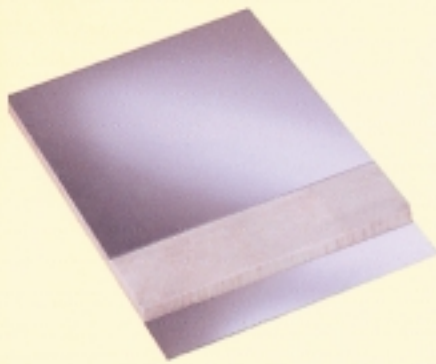


Finished panels come out of the press, ready for final trimming.



This panel is being cut and trimmed. From here it goes into finished goods inventory or to shipping.



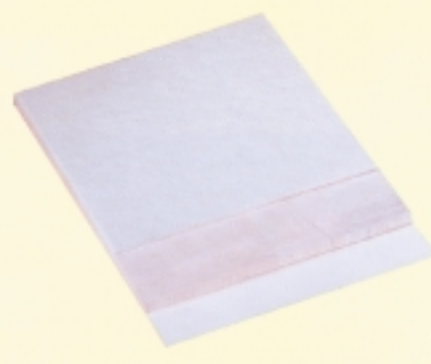


#### **Aluminum Facings/Balsa Wood Core**

End grain balsa wood has performed well for over 30 years within the aircraft industry, but balsa as core is not well known and often viewed with skepticism outside the aircraft and marine industries.

*Pluses:* Very good stiffness and core shear (when the core fails before the facings); relatively low cost; good thermal insulation; simple edge sealing with liquid sealant; and very good point load resistance.

*Minuses:* Relatively heavy with only two core weights of 6.5 lbs/ft<sup>3</sup> and 9 lbs/ft<sup>3</sup> available; aluminum corrodes without proper treatment; aluminum facings less dent resistant than FRP; and panel will absorb water unless edges are properly sealed and proper adhesive used.

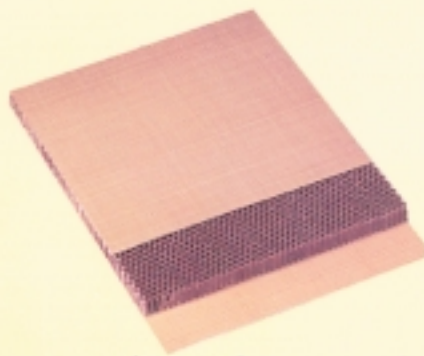


#### **FRP Facings/Balsa Wood Core**

Closely akin to the aluminum/balsa panel, it is usually made with woven fiberglass cloth as reinforcement in the facings. These panels have features making them particularly suitable for aircraft flooring but are also used in many other applications.

*Pluses:* Solid core and FRP facings provide excellent dent and point load resistance; relatively low cost considering the panel's durability; completely non-metallic, therefore corrosion resistant; excellent fatigue resistance; radar transparent and electrical insulation.

*Minuses:* Heavier than some newer types of panels with same strength properties; and will absorb water unless edges are properly sealed.

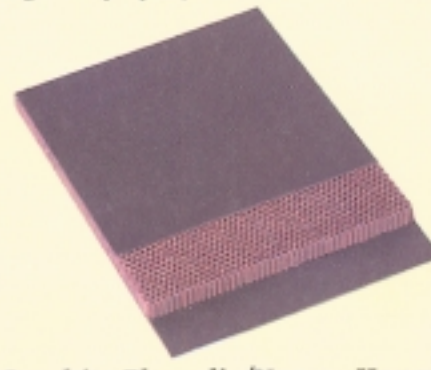


#### **FRP Facings/Nomex® Honeycomb Core**

Nomex honeycomb is made from an aramid fiber paper and is a very resilient core material. Either unidirectional or woven fiberglass facings are used. This panel is often used for aircraft flooring and other interior panels, and is seeing use in a few specialized non-aircraft markets.

*Pluses:* Highly fatigue resistant core; light, low smoke configuration possible; completely non-metallic, therefore corrosion resistant; very low density core available and when combined with various facing thicknesses provides good flexibility in design; radar transparent; can be formed into simple curves; and core absorbs shock well.

*Minuses:* Tendency for edge delamination when cutting if facings are unidirectional; high smoke emission level if epoxy adhesive and epoxy facing resin (lower smoke emission with phenolic resins); high initial cost; needs edge treatment; and honeycomb cells may fill with liquid if facing is punctured.



#### **Graphite-Phenolic/Nomex Honeycomb Core**

This panel, a relatively new configuration, is made from unidirectional or woven graphite facings bonded to a Nomex honeycomb core. Because of the high cost of the raw materials, its market is limited primarily to aircraft and aerospace applications.

*Pluses:* Light weight; much stiffer than other panels of the same weight; very low density core available and when combined with various facing thicknesses provides good flexibility in design; highly fatigue resistant core; more resistant to repeated high psi loading, such as caster wheels and high heels; and very low smoke emission levels due to phenolic facing resin.

*Minuses:* Graphite dust may short out electrical hand tools during fabrication; galvanic corrosion likely between graphite and adjacent metallic materials unless protected with fiberglass overlays and/or expensive titanium, stainless steel, or composite inserts are used; high initial cost; needs edge treatment; and honeycomb cells may fill with liquid if facings are punctured.



*Lift the pages to see the various steps...  
from raw materials to finished products.*

## Sandwich Panels in Inventory

To review, common sandwich panel components for high performance include:

**Adhesives:** Epoxies, contact (rubber) types, urethanes, polyesters, and modified phenolics.

**Cores:** Aluminum, fiberglass and aramid honeycomb, foam, wood, and I-beam types.

**Facings:** Steel, fiber reinforced composites, aluminum and titanium.

Generally, we inventory the following types of panels:

- Aluminum Facings/Balsa Wood Core
- Aluminum Facings/Aluminum Honeycomb Core
- FRP Facings/Balsa Wood Core
- FRP Facings/Nomex Honeycomb Core

Specifically, the products shown in the following table are stocked for immediate shipment.

Because our customers all have differing specifications, sandwich panels are traditionally custom fabricated. With all the differing thicknesses, lengths, widths, facings, cores, and tolerances, the possible variations in sandwich panel construction are endless, and the M.C. Gill Corporation has historically manufactured panels produced specifically to customer callouts.

Conversely, our corporation also has prided itself on prompt response to customer requests. In fact, it is M.C.'s philosophy that **we do not lose orders because of delivery terms**. Therefore, based on sales history and to support those customers that regularly order the same

### M.C. GILL PANELS IN STOCK—READY FOR SHIPMENT

M.C. GILL PART NUMBER	DIMENSIONS	CONSTRUCTION	COMMON END USES
Gillfloor 4017	.400" x 48" x 144" Facings .015" / .015"	Unidirectional S-2 glass reinforced epoxy faces bonded to Nomex honeycomb core with modified epoxy resin.	Aircraft flooring in passenger compartment. Qualifies to: McDD Drawing BZZ 7002; Lockheed LAC-C-28-1386A.
Gillfab 4030	.250" x 48" x 96" .375" x 48" x 96" .500" x 48" x 96" Facings .020" / .020"	2024T3 aluminum faces, aluminum honeycomb core (1/4" cell size 5052 / .002" foil aluminum honeycomb), modified epoxy adhesive.	General purpose panels for shelving, cabinetry, partitions, bulkheads and multiple other uses.
Gillfab 4105	.375" x 48" x 96" Facings .025" / .025"	Woven E-glass/epoxy faces, 3/16" cell Nomex honeycomb core, modified epoxy adhesive.	Passenger compartment flooring. Qualified to Airbus Industrie TL53/5000/79.
Gillfloor 5007A	.400" x 48" x 144" Facings .030" / .030" and .040" / .020"	FRP faces, 9 pcf end grain balsa wood core	Aircraft passenger compartment flooring, galleys, cabinetry and pallets. Qualifies to Airbus Industrie TL53/5000/79 (cargo compartment flooring only).
Gillfloor 5007B	.400 x 48" x 144" Facings .040" / .020"	Same as 5007A except for a high peel modified polyester adhesive.	Aircraft flooring in high traffic areas. Qualified to United Airlines SHE 2902.
Gillfloor 5007C	.400" x 48" x 144" Facings of wear-resistant FRP, one side, .045" / .025" and facings of wear-resistant FRP, both sides, .045" / .045"	FRP with mat overlay facings/9 pcf end grain balsa wood core, modified polyester adhesive.	Bulk cargo compartment flooring. Proprietary to the M.C. Gill Corporation.
Gillfab 5040	.400" x 48" x 144" Facings .020" / .012"	2024T aluminum faces, 9 pcf end grain balsa wood core, heat setting elastomer adhesive.	Passenger and container compartment flooring.



panels, we do maintain an inventory of the more popular constructions. By doing so, we provide quick turn around time and more economical pricing for most customers, no matter how big or small.

Virtually all of the sandwich panels we inventory were originally developed for use in commercial passenger aircraft and have a minimum of 10 to 25 years of proven in-service history. Since their development, most of these panels have found many other uses. For example, Gillfloor 5007A has been used since 1966 by the Jet Propulsion Laboratory (JPL) in Pasadena, CA as the flooring material of choice for their unmanned gondolas that carry scientific instrumentation into the stratosphere ...to measure everything from changes in the weather to

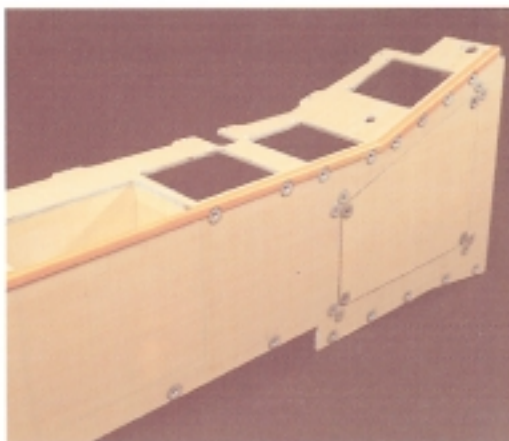
studying closely the effects of the self-destruction of a type II supernova in a neighboring galaxy. Gillfab 4030-type (Gillfab 4101) panels have been used by Ron Jones Marine, Kent, WA, in the design and construction of unlimited hydroplane racing boats, notably the Miss Budweiser, the most successful unlimited hydroplane in the history of the sport. Gillfab 5040 is used as the mounting boards for photographing printing plate negatives in graphic arts cameras.

Some of the above end uses require variations from the configurations of the panels we normally stock. In either case, we make every effort to ensure that the customer is aware of the construction of the panel, its tolerances and load-bearing properties.

## A Myriad of Uses for Sandwich Panels

*...where requirements call for significant reductions in weight, impact strength, rigidity, insulation, fire and smoke resistance.*

*Insulated food cart uses Gillfab 5019 panels with fiberglass facings and polyurethane foam core.*



*An air duct assembly and a pilot's side console storage unit (ready for final detailing) made by Insoleq, Ltd., Belfast, Northern Ireland for the British Aerospace BAe 146-200. Using M. C. Gill's 4004 flat stock, Insoleq cuts, forms, and assembles both units. The air duct assembly jig is shown in the background at the left.*



*The flooring in this DC-10 bulk cargo compartment is Gillfloor 5007C abrasion resistant fiberglass top facing.*

# Trivia

In 1990, Boeing-built airplanes carried more people than live in England, France, Austria, Greece, Egypt, Kenya, Japan, Australia, Peru, Venezuela, Canada, and the United States.

★ ★ ★ ★

Typical wages for today's cowboy are about \$125 for a six-day week.

★ ★ ★ ★

The United States' Ambassador to Mongolia lives in Washington, D.C. the year 'round.

★ ★ ★ ★

The most widely recognized word in the world is "visa."

★ ★ ★ ★

The area of the human body least sensitive to pain is the skin of the heel of the foot.

★ ★ ★ ★

A 2,500 square foot lawn produces enough oxygen for a family of four throughout their lifetime.

★ ★ ★ ★

The fastest spider in the world sprints at 10 m.p.h.

★ ★ ★ ★

Origins of entertainment award names:  
...Oscar (movies) — After an Academy of Motion Picture Arts and Sciences librarian's uncle.

...Grammy (music) — After the gramophone.

...Tony (Broadway plays) — After dancer Antoinette Perry.

...Emmy (TV) — After a television camera part.

★ ★ ★ ★

## THE FUNNY SIDE

Reporter: "To what do you attribute your success?"  
Millionaire: "I just try to make an honest living, and, believe me, there isn't much competition."

★ ★ ★ ★

It's an odd and rather nice thing about aging. The closer you approach a particular age, the younger it seems to become.

★ ★ ★ ★

If you want to improve someone's hearing, praise him.

★ ★ ★ ★

If you exercise, you'll add five years to your life...but you'll spend those five years exercising.

★ ★ ★ ★

Lots of people are in debt because they spend what their friends think they make.

★ ★ ★ ★

Here's the problem: three thousand dieticians are helping us lose weight and three million bakers are helping us find it.

★ ★ ★ ★

"I love this new hearing aid. It's absolutely terrific."

"What kind is it?"

"Fifteen after nine."

★ ★ ★ ★

"What did you and your partners call your new cattle ranch?" a friend asked a newly transplanted Easterner. "We had a terrible time deciding on a name, so we settled on the Lazy-Z, Triple-M-Diamond, Circle-Lucky-7 Ranch," the dude replied. "Wow," gulped the friend, "how many head of cattle do you have?" "None, they didn't survive the branding."

★ ★ ★ ★

A young feminist and an older man arrived at the door simultaneously and the man reached to open it. "You don't have to do that just because I'm a lady," she said. "I'm not holding it for you because you're a lady," he replied, "I'm doing it because I'm a gentleman."

★ ★ ★ ★



M.C. GILL CORP. • SINCE 1945