

The Doorway

A Publication of The Gill Corporation

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Volume 59 - Number 1 - Winter 2023



BOEING 787



ANTIMICROBIAL TREATED

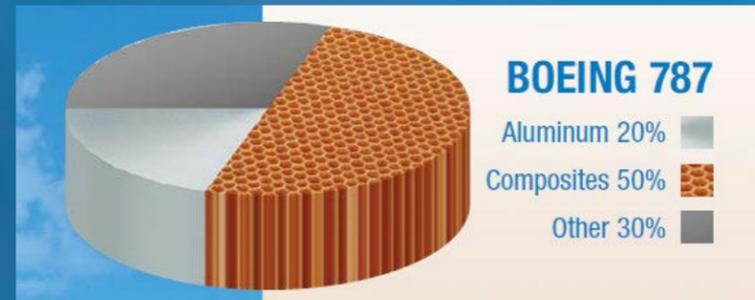


It has been more than 65 years since jet engines revolutionized commercial air travel. Since then, aircraft designs have continued to advance creating demand for new materials and technologies. Recent advancements include more efficient (and lower emission) engines, aerodynamic and wing design changes, and the increasing use of composite materials in aircraft construction. Although advanced composite materials characteristically exhibit high strength-to-weight ratios, the designs of the 21st century have driven the requirements for unprecedented weight savings and performance characteristics.

In 2003, Boeing launched the 787 Dreamliner, a twin-aisle, long-range aircraft focused largely on efficiency, lower operating costs, and environmental impact. Designed with lightweight structures that are 50% composite, the B787 reduces fuel burn and CO₂ emissions by 20-30% and is the first major commercial aircraft to use carbon fiber composite in the fuselage and wings.¹ Due to its efficiency, capacity, and range, the B787 enables airline operators to optimize fleet and network performance, including increased 'point-to-point' service. As of December 2022, total orders for B787 reached 1,608 with 1,039 aircraft delivered.²



**20%
LESS
FUEL**



DREAMLINER



TGC EXPERTISE AND VERTICAL INTEGRATION DELIVER

In 2000, as original equipment manufacturers (OEMs) were finalizing designs for next generation aircraft, The Gill Corporation (TGC) commenced a new product development program of its own. The objective was to develop and characterize a portfolio of ultra-lightweight honeycombs, floor panels, interior panels, cargo compartment liners, and lightning strike protection using a combination of new materials and processes. Between 2000 and 2007, TGC introduced seven new product designs, each having multiple configurations to support a variety of in-service conditions.

Key to the success of this development program was not only TGC's expertise in fiber reinforced plastics and sandwich panel design, but its ability to develop and optimize individual components within its vertically integrated manufacturing environment. The scope of this program included the development of a new para-aramid honeycomb, formulation of new resin matrices, development of a lighter weight film adhesive, and tailoring of the reinforcements, aerial fiber weight and resin content of prepregs.

Today, TGC supports the B787 program with a portfolio of ultra-lightweight honeycomb, machined honeycomb details, floor panels, interior panels, cargo compartment liners, lightning strike protection, and fabricated floor panel kits.



¹ Boeing 787: A Matter of Materials – Special Report – Anatomy of a Supply Chain¹ IndustryWeek.com, December 1, 2007.

² https://en.wikipedia.org/wiki/Boeing_787_Dreamliner

FLOOR PANELS – PASSENGER AND CARGO COMPARTMENT

Gillcore® HK Delivers Weight Reduction to Sandwich Structures

In general, the weight of a sandwich panel is equally divided between the honeycomb core and the combined weight of the facings and adhesive. Understanding how each of these constituent materials contribute to the overall panel properties, and the ability to tailor the weight and performance characteristics of each, is fundamental to design optimization.

In 2000, TGC commenced development of a second-generation aramid honeycomb, Gillcore® HK, which became the cornerstone for TGC's ultra-lightweight floor panel designs. Gillcore® HK is a high-performance honeycomb manufactured using para-aramid paper that is coated with phenolic resin. As a saturable substrate, para-aramid becomes a true composite cell wall when converted to honeycomb, yielding exceptional shear strength and modulus, stiffness, durability, fatigue and hot/wet properties. These superior characteristics make it possible to achieve values that are equal to or higher than meta-aramid at a significant weight reduction of core density. Most configurations of Gillcore® HK can be manufactured using different thicknesses of para-aramid paper, allowing for optimization of key properties geared to specific applications.

For more than 25 years, carbon faced panels with meta-aramid honeycomb core were the industry standard for light weight floor panels. Beginning in 2001, advancing aircraft designs, coupled with emerging new technologies, challenged the status quo. For the B787 program, TGC was tasked with developing a range of floor panels that would meet or exceed the mechanical properties of the applicable Types of BMS 4-17 and BMS 4-20 at a significantly reduced weight. The weight savings, achieved in part by replacing the meta-aramid honeycomb with para-aramid honeycomb, are highlighted by Type in Table I to the right.



Gillfab® 4809, qualified to BMS 4-20, is an ultra-lightweight, high-strength floor panel made from unidirectional carbon fiber-reinforced epoxy facings bonded to Gillcore® HK para-aramid honeycomb core. The outer facing surfaces feature a thin glass isolation barrier to prevent galvanic corrosion.

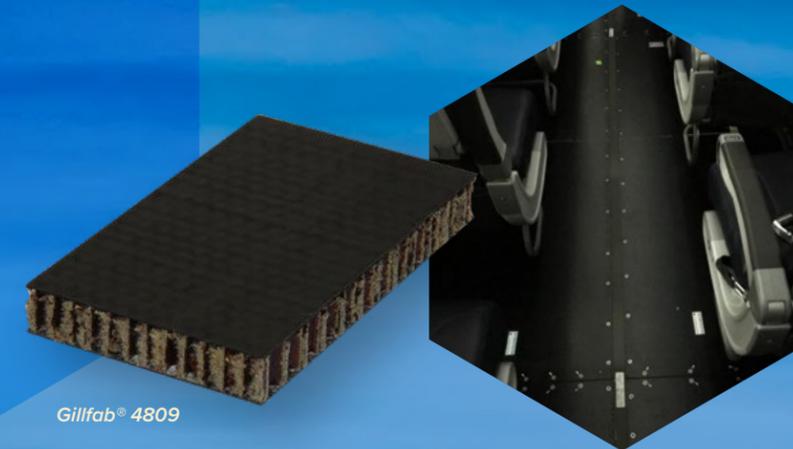
Gillfab®4809 is available in the following Types:

Type VI - 0.400" overall thickness, 2 ply unidirectional carbon reinforced facings, 4.5 pcf para-aramid core. Designed for use in low traffic/underseat areas.

Type VII - 0.400" overall thickness, 2 ply unidirectional carbon reinforced facings, 6.5 pcf para-aramid core. Designed for use in aisles and entries.

Type VIII - 0.400" overall thickness, 2 ply unidirectional carbon reinforced facings, 8.0 pcf para-aramid core. Designed for use in utility/highly loaded areas.

Type IX - 0.400" overall thickness, 2 ply unidirectional carbon reinforced facings, 11.0 pcf para-aramid core. Designed for use in galley areas.



Gillfab® 4809



TABLE I

Gillfab® 4809 Type	Weight, psf (maximum)	Replacement for	Weight, psf (maximum)	% Weight Savings
Type VI	0.42	BMS 4-20 Type III	0.46	8.7%
Type VII	0.48	BMS 4-20 Type II	0.58	17.2%
Type VIII	0.59	BMS 4-17 Type VI	0.8	26.3%
Type IX	0.79	BMS 4-17 Type V	1.1	28.2%

Gillfloor® 4809G (GillIVANA®), qualified to BMS 4-20 Types X and XI, features the same basic panel construction as 4809 except that the honeycomb is coated with GillIVANA®, a synthetic viscoelastic coating that integrates acoustic damping technology. This product brings about acoustic benefits while still meeting physical, mechanical and FST requirements. Sandwich panels can be optimally designed to deliver improved acoustics for specific applications. GillIVANA® panels are ideal for aircraft interior sandwich panel applications such as flooring and sidewalls.



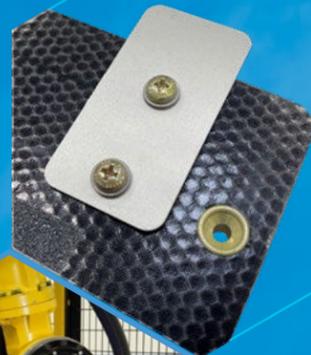
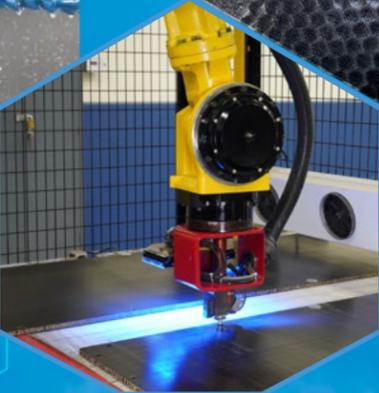
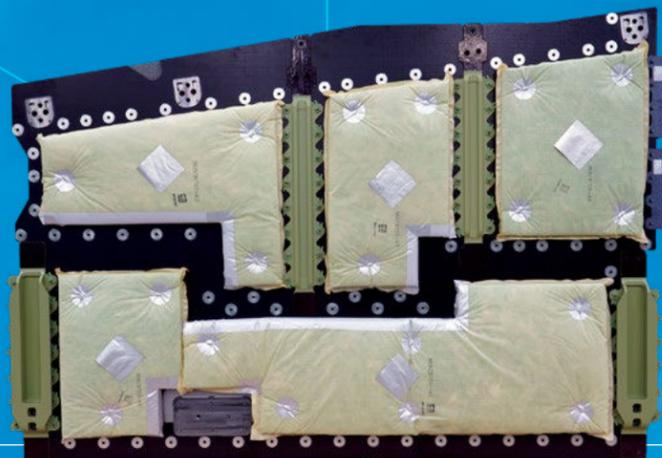
GillIVANA®
proprietary
process

Fabricated Floor Panel Kits

TGC's support of the B787 program includes the fabrication and kitting of cabin and cargo floor panels utilizing our in house fabrication capabilities that include:

- 3-axis cutting and routing
- In house precision machining of metallic fittings and intercostals
- Installation of hardware components
- Edge closeouts
- Wet lay up
- Painting and priming
- Vacuum bag oven cure

Once completed, each floor panel assembly is inspected using a coordinate-measuring machine (CMM), labeled and covered with a protective overlay, as applicable. The finished panels are then kitted and packaged for transportation to either Boeing or its Tier 1 suppliers.



CARGO LINERS

Gillfab® 1368G, qualified to BMS 8-223, Class 5, Grade B is an ultra-lightweight, high-impact resistant cargo liner made from woven S-glass reinforcement with a phenolic resin matrix. A white PVF overlay is applied to the face side for reflectivity. The superior strength and low aerial weight of the S-glass reinforcement allow for reduced weight and thickness while maintaining the properties of thicker Types. Gillfab® 1368G exhibits low fire, smoke and toxicity characteristics, and meets 14 CFR Part 25, Appendix F Parts I & III (burn through).



TABLE II

Gillfab® 1368G	Weight, psf (maximum)	Compared to	Weight, psf (maximum)	% Weight Savings
Type 7	0.074	BMS 8-223 Class 2 Type 13	0.13	43.0%
		BMS 8-223 Class 4 Type 13	0.106	30.2%
Type 27	0.275	BMS 8-223 Class 2 Type 40	0.42	34.5%
		BMS 8-223 Class 4 Type 40	0.33	16.7%

Aftermarket Support

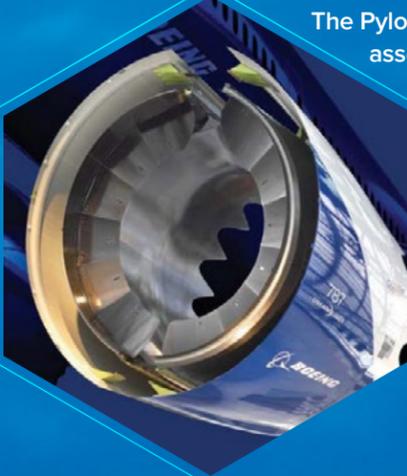
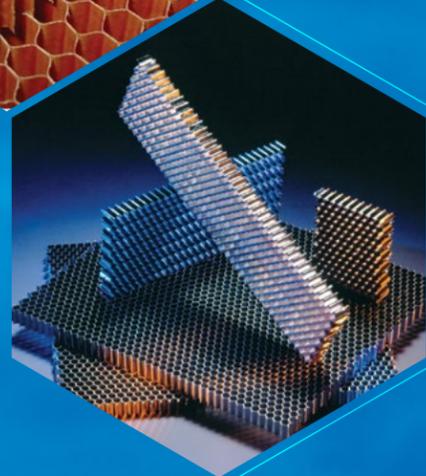
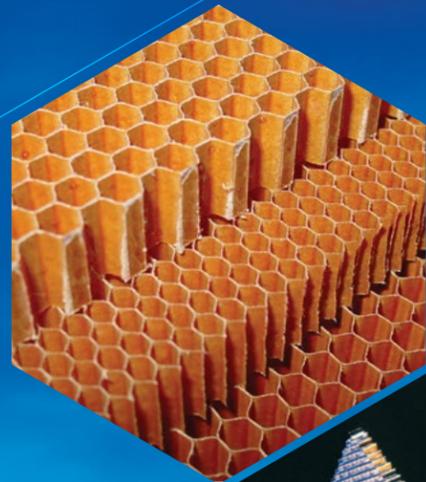
As one of the world's largest manufacturers of OEM qualified floor panels, cargo liners and honeycombs, TGC has a longstanding history supporting both production and aftermarket programs. For airlines and maintenance, repair, and overhaul (MRO) providers, we recognize that material requirements can be difficult to forecast and that quick response times and deliveries are essential. Accordingly, TGC has established an inventory of floor panels and cargo liners to support AOG and urgent requirements.



HONEYCOMB

Honeycomb core is used extensively due to its light weight, high strength-to-weight ratio. When integrated into a sandwich structure, the combination of honeycomb and face sheets function as an I-beam to achieve bending stiffness at a significantly lower cost and weight than a solid structure.

TGC manufactures both aramid and metallic honeycombs in a broad range of cell sizes and densities, assuring the best product for the intended application. Refer to the chart on page 10 to see specific honeycomb offerings.



to conform to multiple radii within a contiguous part. For the TLS and IFS work packages, both Dura-core® and Shapegrid® are 3-axis machined in 'culette' or hobe form, expanded, then stabilized with proprietary heat and vacuum techniques. Depending on specified geometric requirements of the final part configuration, additional 5-axis milling may be performed. Finished parts are furnished to Tier 1 suppliers as individual parts or kitted for further processing.

The Pylon Fairing for the GE engine variant is a complex assembly produced from aramid honeycomb that is formed and machined into complex shapes. Due to forming characteristics inherent to aramid honeycomb, support of this program required significant process development to achieve and maintain the final part configuration. In addition to machining, these fairing details are subjected to multiple heat forming cycles to achieve the required part geometry. Once the final configuration is set, stabilizing film is applied and final features including potting, cutouts, steps and chamfering are completed. All parts are supplied to Tier 1 customers as clean core, ready for next assembly bonding.

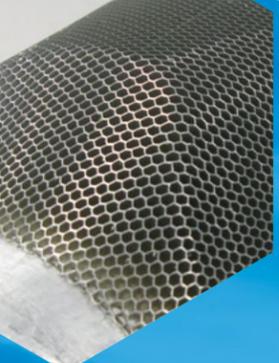


MACHINED HONEYCOMB

The increasing use of composite materials in contemporary aircraft designs has not only driven demand for advanced materials and technologies; it has also created requirements for new equipment and processes for producing complex composite structures. Flight control surfaces and aerodynamic structures are generally contoured and represent varying degrees of complexity. As such, honeycomb used in these applications must be precision machined and stabilized before skins can be applied. As a leading manufacturer of honeycombs, TGC anticipated the need to expand its manufacturing capabilities to ensure its ability to support OEM's and Tier 1 suppliers with not only block and slice honeycomb, but also machined honeycomb details. In 2001, TGC acquired Alcore, Inc, and Alcore Brigantine, known today as The Gill Corporation-Maryland (TGC-Maryland) and The Gill Corporation-France (TGC-France).

Consistent with TGC's philosophy of vertical integration, this acquisition not only brought the manufacture of metallic honeycomb in-house, but also established centers of excellence (COE) for honeycomb machining and special processing in both Europe and North America. Since then, TGC has established a third COE at its headquarters in El Monte, California USA. Today, TGC supports the B787 program with honeycomb in various configurations. Machined honeycomb programs include the Thrust Reverser Translating Sleeves (TLS) and Inner Fixed Structure (IFS) for the GE and Rolls Royce engine variants and Pylon Fairing work package.

The TLS and IFS programs are produced from metallic honeycomb core that is manufactured by TGC-Maryland. At the inception of the IFS program, a proprietary honeycomb known as Shapegrid® was developed and qualified for this work package. Shapegrid® is a highly customizable variant of Dura-core® or PAA that optimizes node lines to enable the honeycomb

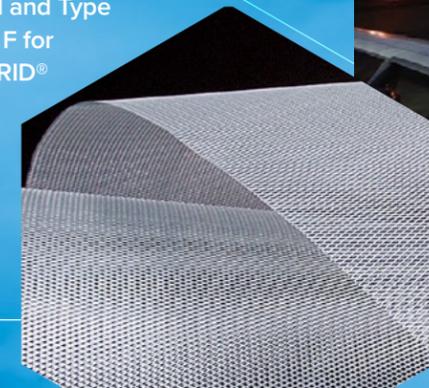


STRIKEGRID®

With advances in the use of composites to fabricate aircraft structures, including use of much more composite materials in the fuselage, new systems for dealing with lightning strikes are being introduced.

In 2004, TGC introduced PAA Strikegrid® Continuous Expanded Aluminum Foil (CEAF). It is the industry's highest-performing lightning-strike dissipation material. Phosphoric acid anodized (PAA) and coated with a proprietary coating, it outperforms all other ductile materials. Decades of operational experience have shown that bond durability between lightning-strike materials and face sheets or surfacing materials is critical to long part life; and for this, PAA-Strikegrid® foil has no equal.

Strikegrid® materials are qualified to Boeing BMS 8-336, material specification for Type 1, Class 2, Grade 013, Form B, Style F for SG-3, 2 mil thick material and Type 1, Class 2, Grade 016, Form B, Style F for SG-4, 4 mil thick material. STRIKEGRID® CEAF is currently used on Boeing B737, B777, B787, and B747-8.



HONEYCOMB

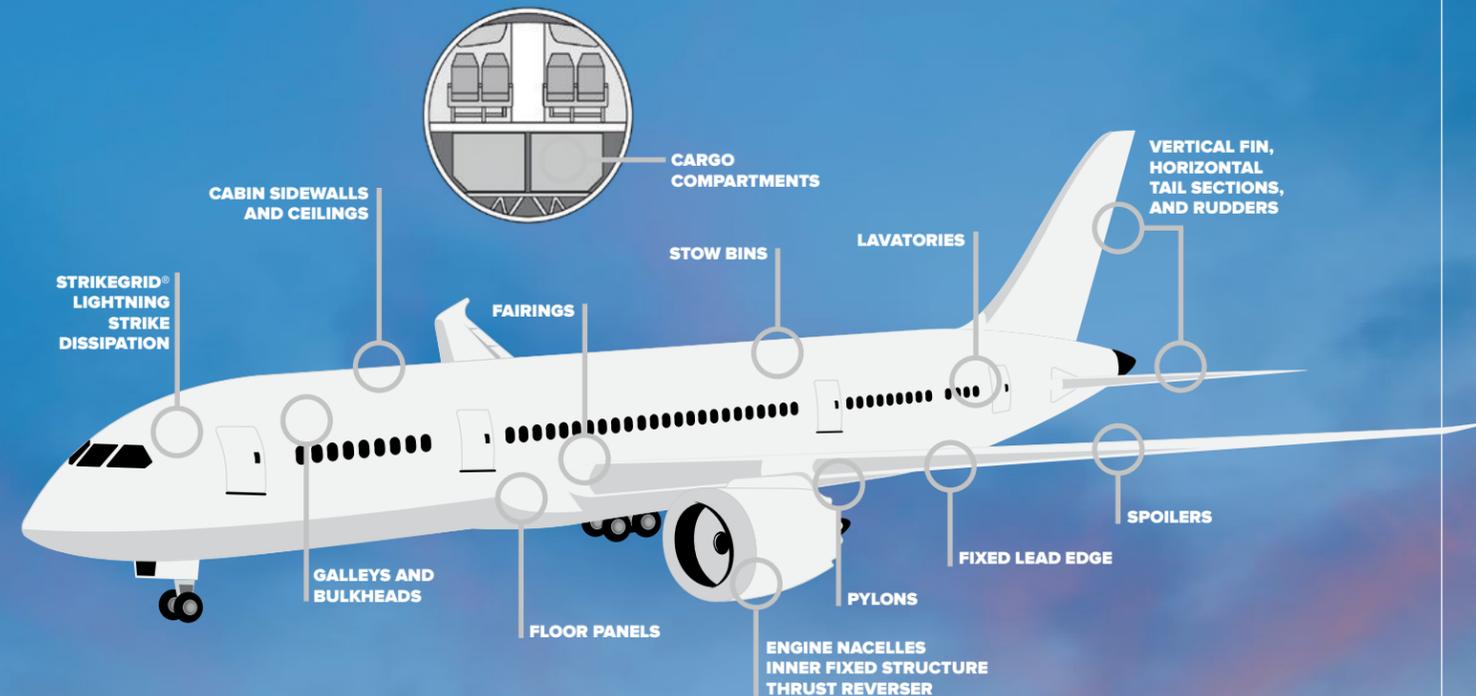
PRODUCT	DESCRIPTION	CORE	STRENGTH	APPLICATION	SPECIFICATION
Gillcore® HD	Meta-aramid fiber reinforced honeycomb which is coated with heat resistant phenolic resin.	Meta-aramid honeycomb	High strength-to-weight ratio	Interior aircraft panels including flooring, sidewalls, ceilings, galleys and lavatories. Exterior aircraft panels including trailing and leading edges, flaps, ailerons, fairings, helicopter blades, access panels and doors.	BMS 8-124 Class IV, Types I-VI
Gillcore® HK	Para-aramid fiber reinforced honeycomb which is coated with heat resistant phenolic resin.	Para-aramid honeycomb	High shear strength and modulus.	Interior aircraft panels including flooring, sidewalls, ceilings, galleys and lavatories. Exterior aircraft panels including trailing and leading edges, flaps, ailerons, radomes, fairings, helicopter blades, access panels and doors.	BMS 8-124 Class VI, Types V and VI
Dura-Core® II 5052 and 5056	Aluminum honeycomb which provides the aerospace and commercial markets with a high degree of flexibility in solving lightweight structural design challenges.	Aluminum honeycomb	Excellent corrosion resistance in hostile environments, especially salt fog. Prior to bonding, the foil is cleaned and treated using a proprietary chemical conversion coating.	Airframe / Interiors - high degree of flexibility in solving light weight structural design challenges.	BMS 4-4 Class N, P, ND, Grade I, Types All
PAA-Core® 5052	Aluminum honeycomb made from phosphoric acid anodized foil yielding high corrosion resistance with excellent bonding capability and durability.	Aluminum honeycomb	Highest performing core material - high strength-to-weight ratio. Corrosion resistance and phosphoric acid anodized and coated with a proprietary primer, it outperforms all other core materials.	Airframe and nacelles.	BMS 4-4 Class NPA, Grade I, Types All
PAA-Core® 5056	Aluminum honeycomb made from phosphoric acid anodized foil yielding high corrosion resistance with excellent bonding capability and durability.	Aluminum honeycomb	Highest performing core material - high strength-to-weight ratio. Corrosion resistance and phosphoric acid anodized and coated with a proprietary primer, it outperforms all other core materials.	Airframe and nacelles.	BMS 4-25 Class All, Grade I, Types 6-30, 6-40, and 2-30
Shapegrid®	Custom-contoured honeycomb that can be customized to meet tight radial requirements, while maintaining normal cell axis alignment.	Aluminum honeycomb	Corrosion resistance in hostile environments, especially salt fog.	Airframe and nacelles.	Qualification information available upon request

LAMINATES

PRODUCT	MATERIAL	RESIN	STRENGTH	APPLICATION	SPECIFICATION
Gillfab® 1367B/1368B	Woven S-glass with white Tedlar® overlay on the face side	Phenolic	Lightweight, high impact resistance; low smoke and toxicity grade.	Sidewalls, ceiling, partition walls and bulkhead of lower cargo hold and main deck (freighter).	BMS 8-223 Class 4, Grade B
Gillfab® 1367G/1368G	Woven S-glass with white Tedlar® overlay on the face side	Phenolic	Ultra lightweight, high impact resistance; low smoke and toxicity grade.	Sidewalls, ceiling, partition walls and bulkhead of lower cargo hold.	BMS 8-223 Class 5, Grade B

PANELS

PRODUCT	FACING	RESIN	CORE	STRENGTH	APPLICATION	SPECIFICATION
Gillfloor® 4809	Unidirectional carbon fiber with lightweight woven glass scrim	Epoxy	Para-aramid honeycomb	Lightweight, high strength	Under seat, aisle	BMS 4-20 Types VI, VII, VIII and IX
Gillfloor® 4809G	Unidirectional carbon fiber with lightweight woven glass scrim	Epoxy	Para-aramid honeycomb coated with proprietary visco elastic coating	High strength, vibration and acoustic dampening.	Aisles, entries, utility and galley areas.	BMS 4-20 Types X and XI



This is not an all inclusive list of where TGC products are used. TGC metallic and non-metallic honeycomb cores are sold to customers around the world for use in many applications across the Boeing 787 aircraft.

ALUMINUM FOIL

PRODUCT	MATERIAL	STRENGTH	APPLICATION	SPECIFICATION
Strikegrid®	Strikegrid® CEAF is a phosphoric acid anodized (PAA) continuous expanded aluminum foil (CEAF) product that also includes a proprietary coating which combines to negate the effects of galvanic corrosion when used in conjunction with carbon prepreg materials.	Superior protection versus industry incumbent copper and phos-bronze mesh products of similar thickness and composition.	Strikegrid® can be bonded to aircraft structures either as an outer ply or embedded 'one-ply down' beneath a layer of surfacing film.	BMS 8-336 Type 1, Class 2, Grade 013, Form B, Style F for SG-3, 2 mil thick material and Type 1, Class 2, Grade 016, Form B, Style F for SG-4, 4 mil thick material.



Quotables

If 99% is good enough then gravity will not work for 14 minutes every day.

-Unknown

You don't want to be considered just the best at what you do. You want to be known as the only one who does what you do.

-Bill Graham, Concert Producer

There are two kinds of people, those who do the work and those who take the credit. Try to be in the first group; there is less competition there.

-Indira Gandhi, Prime Minister of India

If there's a 50/50 chance something can go wrong, then nine times out of ten it will.

-Paul Harvey, Commentator

The truth does not emerge from opinion.

-David Bohm, Physicist

Winners have simply formed the habit of doing things losers don't like to do.

-Albert E.N. Gray, Author

The best ideas for improving a job come from those who do it every day.

-Jim Bleech, Vistage Speaker

Rather than focusing on the obstacle in your path, focus on the bridge over the obstacle.

-Mary Lou Retton, Olympic Gymnast

The main thing is that you keep the main thing the main thing.

-Albert Einstein, Physicist

The right people don't think they have a job; they have responsibilities.

-Jim Collins, Author

Whatever it takes, that's what I do.

-David Mellor, Baseball Player

There are no absolutes. Absolutely none.

-Richard Hanson, SyncroFlo

There are no exceptions to the rule that everybody likes to be an exception to the rule.

-Charles Osgood, Journalist

To achieve great things two things are needed: a plan and not quite enough time.

-Unknown

There's no traffic jam on the extra mile.

-Howard Hyden, Vistage Speaker

Technique and ability alone do not get you to the top; it is the willpower that is most important.

-Junko Tabei, First Woman to Summit Mount Everest



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