THE GILL CORPORATION

BOEING®

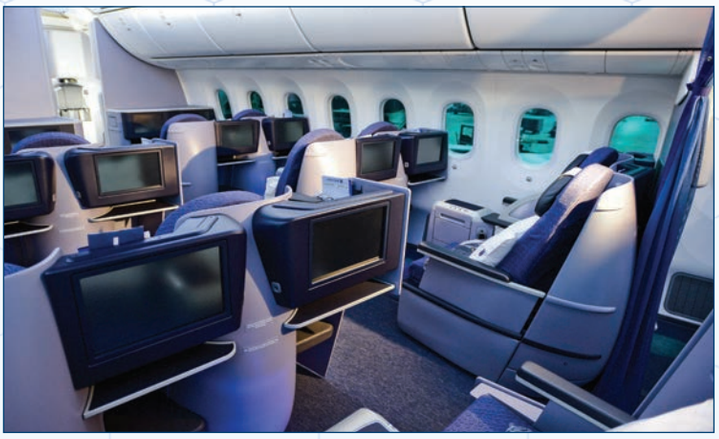
787 DREAMLINER PRODUCTS OVERVIEW

The Gill Corporation – High Performance Composites Innovation Supporting Cutting-Edge Design

The Boeing 787 Dreamliner is the first commercial jet to have a majority of the primary structure – including the wing and fuselage – made of advanced composite materials. Designed to achieve 20% greater fuel efficiency than its predecessor, the B787 relies in part on the weight savings of composite materials to realize this objective. From the early B787 design phase, Boeing challenged their suppliers to keep pace with advancing technologies to deliver products meeting their stringent strength and weight requirements. They found a viable partner in The Gill Corporation (TGC).

As a pioneer in the design and manufacture of high performance composites, TGC's vertically integrated manufacturing environment, which spans from new product innovation to fabricated assemblies, proved fundamental to its success in supporting the B787 program. By producing not only finished products but also constituent materials, TGC capitalized on its ability to tailor the aerial fiber weight and resin content of prepregs, develop a lighter weight film adhesive, and commercialize new configurations of para-aramid honeycomb to meet Boeing's exacting requirements.

The resultant portfolio of products, which includes honeycomb core, floor panels, interior panels and cargo liner, offers unprecedented weight and performance characteristics.



B787 INTERIOR

Aramid honeycomb core is used extensively in aircraft interior structures due to its light weight, high strength-to-weight ratio and compliance to the flammability requirements of FAR 25.853. 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.

Aramid honeycombs can be shaped, cut and bonded using standard industry methods or heat formed to achieve more complex shapes. Interior structures which typically utilize honeycomb core include floor panels, sidewalls, ceilings, stowage bins, class dividers, bulkheads, lavatories and galleys.

Sidewall Panels and Interior Structures – Gillcore® HD

Gillcore® HD is a first generation aramid honeycomb manufactured using meta-aramid paper coated with phenolic resin. Initially adopted into aircraft design more than 35 years ago, meta-aramid honeycomb offers high shear and compression strength and modulus, with good fatigue resistance. While successive aramid materials have been developed to support exceptional design requirements, Gillcore® HD remains a benchmark material, offering a good balance between cost, weight and performance.

Gillcore® HD is available in a wide range of cell sizes ranging from 1/8" (3.2mm) to 1/4" (6.35mm) and densities ranging from 1.8 pcf (28.8kg/m^3) to 12.0 pcf (192.2kg/m^3), in both hexagonal and over-expanded cell geometries. It is qualified to Boeing BMS 8-124 Class 4 Type I Grades 2.0, 3.0 and 4.0; Type II Grade 4.0; Type V Grades 1.8, 3.0, 4.0, 5.0, 8.0 and 9.0; and Type VI Grades 1.8 and 3.0.

Stow Bins and Monuments - Gillcore® HK

Gillcore® HK is a second generation, high performance aramid honeycomb manufactured using para-aramid paper with phenolic resin. As a saturable substrate, para-aramid paper becomes a true composite when converted to honeycomb, delivering exceptional shear strength and modulus, fatigue resistance and hot/wet properties. For applications currently utilizing meta-aramid honeycomb core, substitution of para-aramid honeycomb may offer significant weight savings potential, depending on specific design requirements.

The general rule of honeycomb is that shear properties are driven by the substrate, compression properties are driven by the resin. The replacement of meta-aramid honeycomb with lower density para-aramid honeycomb is based on the higher shear strength and modulus inherent to para-aramid paper. For applications where shear strength and modulus are the critical properties, it is possible to achieve design allowable values that are equal to or higher than existing meta-aramid values at a significant reduction in core density.

An example of the weight savings potential of replacing 1/8 3.0 pcf (3.2-48kg/m^3) meta-aramid with 1/8 2.5 pcf (3.2-40kg/m^3) para-aramid is shown in Table I.

TABLE I

Property	Typical Properties of Meta-aramid Honeycomb 1/8 3.0# (3.2-48kg/m^3)	Typical Properties of Para-aramid Honeycomb 1/8 2.5# (3.2-40kg/m^3)	Weight Savings
Stabilized Compression, psi (Mpa)	329 (2.27)	321 (2.21)	16.6%
L Shear, psi (Mpa)	224 (1.54)	272 (1.87)	
L Modulus, ksi (Gpa)	7.26 (.050)	16.7 (0.12)	
W Shear, psi (Mpa)	109 (0.75)	156 (1.07)	
W Modulus, ksi (Gpa)	3.97 (.027)	7.9 (0.05)	

TABLE II

Property	Typical Properties of Para-aramid Honeycomb 1/8 3.0 pcf (3.2-48kg/m^3) Manufactured with 1.4 mil (36 µm) para-aramid paper	Typical Properties of Para-aramid Honeycomb 1/8 3.0 pcf (3.2-48kg/m^3) Manufactured with 1.8 mil (46 µm) para-aramid paper
Stabilized Compression, psi (Mpa)	422 (2.91)	403 (2.78)
L Shear, psi (Mpa)	281 (1.94)	304 (2.09)
L Modulus, ksi (Gpa)	17.8 (0.12)	22.2 (0.15)
W Shear, psi (Mpa)	146 (1.01)	164 (1.13)
W Modulus, ksi (Gpa)	8.2 (0.06)	10.5 (0.07)

Because most densities of Gillcore® HK can be manufactured using different thicknesses of para-aramid paper, this product also offers a broad range of design flexibility. Within certain parameters, paper thickness can be increased or decreased to optimize shear, modulus and compression properties at the most economic cost point.

A comparison of the typical properties of 1/8" cell, 3.0 pcf (3.2-48kg/m^3) para-aramid honeycomb produced with 1.4 mil (36µm) and 1.8 mil (48µm) paper is shown in Table II.

Gillcore® HK, qualified to BMS 8-124 Class 6, Type V, Grades 2.5, 3.0, 4.0, 6.0 and Type VI Grade 2.5, has been developed and commercialized in both hexagonal and over-expanded cell configurations. It is available in cell sizes ranging from 1/8" (3.2mm) to 3/16" (4.8mm) and densities ranging from 2.0 to 11.0 pcf (32 kg/m^3 to 172 kg/m^3).

With typical weight savings potential of 15-40% over meta-aramid, Gillcore® HK is the new standard for ultra light weight composite structures.

Cabin and Containerized Cargo Floor Panels – Gillfloor® 4809

For more than 25 years, Carbon/meta-aramid panels have served as the industry standard for light weight flooring, delivering an average weight savings of 12% versus glass/honeycomb panels with comparable strength. Beginning in 2001, however, 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 achieve unprecedented weight reduction while adhering to the stringent mechanical properties of existing Boeing floor panel specifications.

Typically, the weight of a sandwich panel is equally divided between the facings and adhesive and the honeycomb core. Therefore, understanding how each constituent material contributes to the overall panel properties and having the capability and expertise to tailor the weight and performance characteristics of each component is fundamental to panel optimization. Gillfloor® 4809, qualified to Boeing Specification BMS 4-20 Types VI through IX was developed using a combination of new material technologies and manufacturing processes to introduce a panel having exceptional strength-to-weight ratio.

Gillfloor® 4809 is a high strength, ultra light weight floor panel made from unidirectional carbon fiber reinforced epoxy facings bonded to Gillcore® HK para-aramid honeycomb using a Gill proprietary epoxy film adhesive. The unidirectional facings, which are cross-plied at a 0°, 90° orientation and feature a light weight glass scrim on the outer surfaces for galvanic protection, support maximum weight reduction and yield higher impact resistance and bending stiffness at a lower cost than woven carbon fiber. The Gillcore® HK variants, developed specifically for use in Gillfloor® 4809, have been adapted to yield an ideal balance of shear and compressive properties critical to floor panel performance. Gillfloor® 4809 is available in four different configurations to address the varying in-service conditions within the cabin and cargo areas.

As shown in Table III below, Gillfloor® 4809 offers a weight savings over current designs ranging from 13.0% in low-traffic areas to over 37% in galleys and highly loaded areas.

TABLE III

Gillfloor® 4809	Weight, psf. (Maximum)	Replacement for	Weight, psf. (Maximum)	Weight Savings
Type VI	0.40	BMS 4-20 Type III	0.46	13.0%
		BMS 4-17 Type I	0.52	23.07%
		BMS 4-23 Type I	0.55	27.3%
Type VII	0.46	BMS 4-20 Type II	0.58	20.7%
		BMS 4-17 Type II	0.64	28.1%
		BMS 4-23 Type II	0.64	28.1%
Type VIII	0.58	BMS 4-17 Type VI	0.80	27.5%
Type IX	0.69	BMS 4-17 Types V and IX	1.10	37.3%

BMS 4-20 Type X and XI

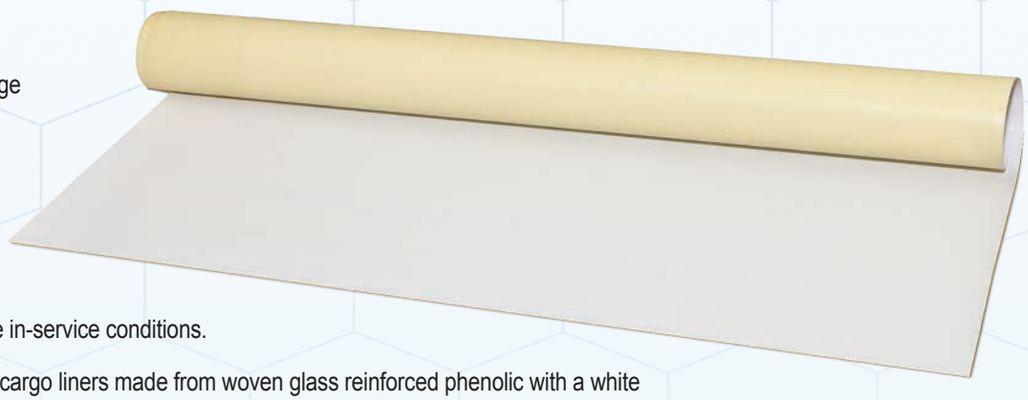
Gillfab® 4809G (GillVANA®) is the same construction as a 4809 except that the honeycomb is coated with GillVANA®, a synthetic viscoelastic coating that integrates acoustic damping technology. This product brings about acoustic benefits while still meeting physical, mechanical and FST requirements. Sandwich panels can be optimally designed to deliver improved acoustics for specific applications with minimal weight addition. GillVANA® panels are ideal for aircraft interior sandwich panel applications such as flooring and sidewalls.

Flight Deck Bulkhead – Gillfab® 5609

Gillfab® 5609 is a high strength, ultra light weight sandwich panel made from unidirectional carbon fiber reinforced phenolic facings with a glass scrim overlay,

bonded to Gillcore® HK para-aramid honeycomb core, using a Gill proprietary phenolic film adhesive. While similar in construction to Gillfloor® 4809, Gillfab® 5609 is designed to meet the rigorous fire, smoke and toxicity requirements of FAR 25.853 Appendix F, Parts I, IV and V. Gillfab® 5609 is ideal for use in cabin interior structures where weight is a primary consideration. By modifying the overall panel thickness, the number and orientation of carbon plies and the configuration of para-aramid honeycomb core, this product can be tailored to meet even the most exacting specifications.

B787 Cargo Sidewall and Ceiling Liner - Gillfab® 1367G/1368G



Cargo liner is an important design feature of a baggage compartment, serving as both a passive fire protection and a safeguard to prevent damage from the loading, unloading or shifting of cargo. While the flammability characteristics of a cargo liner are of primary importance, it is equally essential that the mechanical strength be commensurate to the in-service conditions.

Gillfab® 1367G/1368G are light weight, high strength cargo liners made from woven glass reinforced phenolic with a white Tedlar® overlay on the face side for reflectivity. The design, which relies on the superior tensile strength and modulus of S-glass, provides equivalent impact and edge-bearing strength at a thinner, lighter gauge than earlier designs. Gillfab® 1367G/1368G are compliant with all requirements of FAR Part 25, Appendix F, Parts I and III (flame penetration resistance) with the added benefit of low smoke and toxicity characteristics, inherent to the phenolic resin matrix. Gillfab® 1367G/1368G are qualified to Boeing specification BMS 8-223, Class 5, Grade B, Types 7 and 27.

The weight savings potential of Gillfab® 1367G/1368G is referenced in Table IV.

TABLE IV

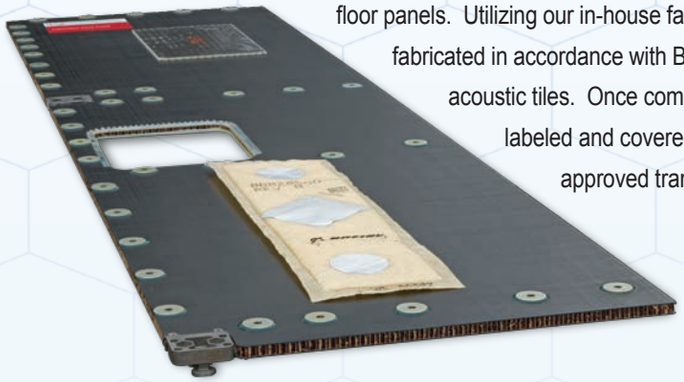
Gillfab® 1367G/1368G	Weight, psf. (Maximum)	Replacement for	Weight, psf. (Maximum)	Weight Savings
Type 7 (.007)	.074	1367A/1368A Type 13 (BMS 8-223 Class 2)	.130	43%
		1367B/1368B Type 13 (BMS 8-223 Class 4)	.106	30%
Type 27 (.027)	.275	1367A/1368A Type 40 (BMS 8-223 Class 2)	.420	35%
		1367B/1368B Type 40 (BMS 8-223 Class 4)	.330	17%

VALUE-ADDED SOLUTIONS

As manufacturers around the globe work to reduce their supply chain, there is a growing necessity to partner with suppliers who offer expanded capabilities to support a wide range of value-added services. TGC, TGC - Maryland and TGC - France offer customers a complete design solution and have become the corporation's centers of excellence for the machining, profiling and heat forming of honeycombs. These facilities currently support major OEM programs with aircraft structure sub-assemblies such as flaps, slats, spoilers, rudders, ailerons and engine nacelles.

B787 Fabricated Floor Panel Kits

TGC's support of the B787 program extends beyond the manufacture of advanced composite materials to include the fabrication and kitting of cabin and cargo floor panels. Utilizing our in-house fabrication capabilities, Gillfloor® 4809 panels are precision cut using CNC routers and fabricated in accordance with Boeing drawings to include features such as hardware, edge-fill, insulation blankets and acoustic tiles. Once completed, each floor panel assembly is inspected using coordinate-measuring machine, labeled and covered with a protective overlay. The finished panels are then kitted by shipset in Boeing approved transport carts and readied for transport to Boeing facilities in Charleston, South Carolina.



B787 Exterior & Engine Nacelles

Structures – Gillcore® HD

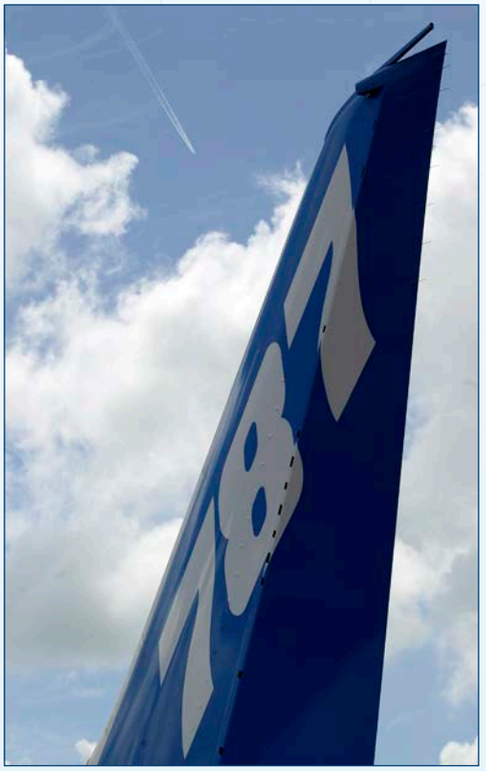
TGC manufactures and then machines honeycomb for engine nacelles, thrust reversers, fixed leading edges of wings, slats, flaps, winglets and continues to fabricate Gillcore® HD meta-aramid fiber reinforced honeycomb core for B787 spoilers and stabilizers. TGC utilizes state of the art 5-axis machines adjacent to the Controlled Contamination Area (CCA) used for processing honeycomb.

Engines – PAA-CORE®

TGC - France serves the European markets with a broad array of core competencies in aerospace-grade structural core materials technology with in-house design and special processing expertise including core details for nacelles. TGC - France currently supplies PAA Core® details for the Thrust Reverse Translating Sleeve.

The Boeing 787 Dreamliner entered commercial service on October 26, 2011. TGC and its subsidiaries are proud participants in the B787 program.

For more information about The Gill Corporation products and services, please visit **www.thegillcorp.com.**



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