The Doorway

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AIRCRAFT CARGO LINERS

80 YEARS

1945 - 2025

ANTIMICROBIAL TREATED

AIRCRAFT CARGO BAY LINING MATERIALS

INNOVATIONS IN FIRE SAFETY, DURABILITY, AND PERFORMANCE

The Gill Corporation (TGC) was founded on September 11, 1945, by Merwyn C. Gill (MC), a visionary who believed in the potential of plastics as a material for the future. Starting in a garage in Montebello, California, MC began the business by producing Wallfab, a durable plastic wallpaper, marking an initial foray into innovative fiber-reinforced plastic (FRP) applications.

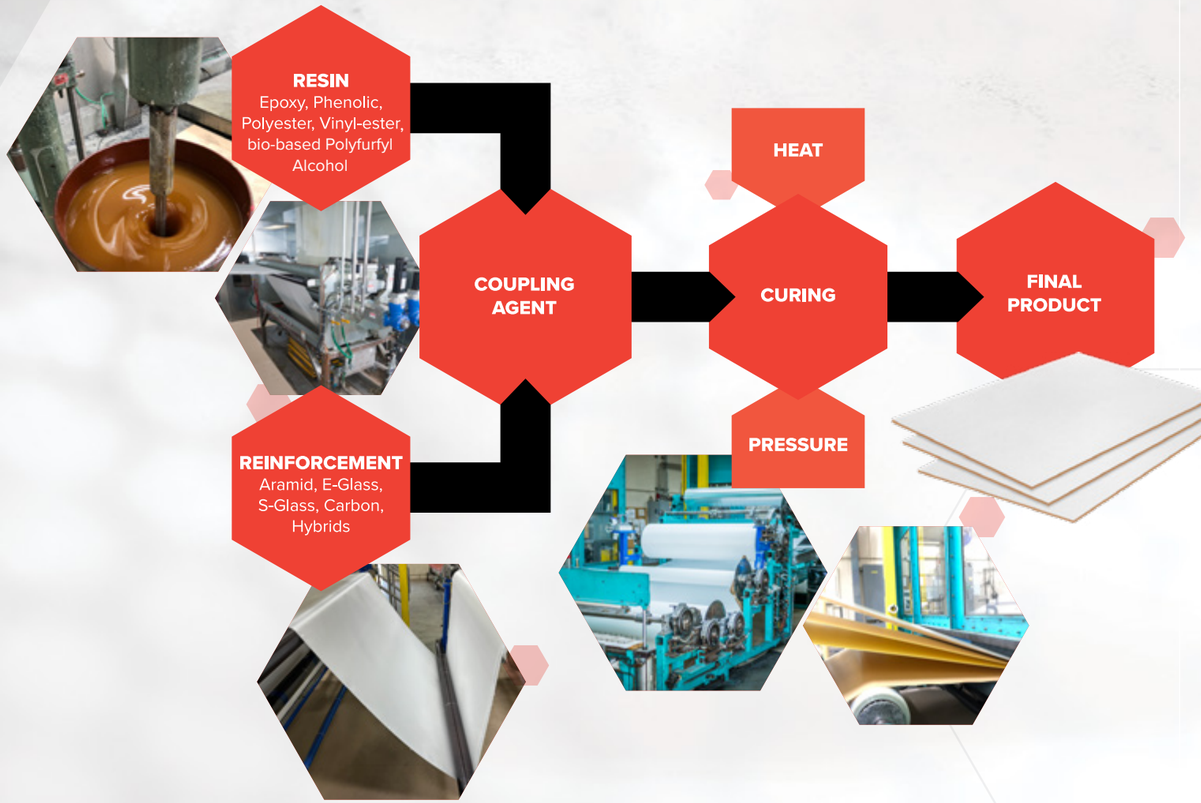
In 1952, Douglas Aircraft Company sought a manufacturer to produce fire-proof materials for the cargo compartment walls of the DC-6 aircraft. MC successfully applied his manufacturing expertise to develop and produce the FRP materials known as Gilliner®, quickly expanding to supply specialty laminates to other aviation customers. Since the beginning, the company has continuously invested in research and development (R&D) and vertically integrated manufacturing to become the premier supplier of cargo lining solutions.

Modern aircraft manufacturers line cargo bay walls and ceilings with FRP laminates, composite sandwich panels, or a combination of these materials. All are designed to meet strict aircraft safety, strength, weight requirements prioritizing fire and smoke protection to ensure passenger and crew safety.

FIBER REINFORCED PLASTICS (FRPs)

This Doorway issue features FRP laminate solutions for aftermarket customers. FRP laminates consist of optimal combinations of glass or carbon fiber reinforcements with polymer resin matrix systems to improve fire containment, abrasion resistance and durability while reducing maintenance costs, and costly Aircraft on Ground (AOG) delays. TGCs advanced material selections and production processes can be tailored to meet exacting customer requirements by adjusting:

- Resin matrix
- Type of reinforcement
- Amount of reinforcement
- Fiber orientation
- Surface veil
- Manufacturing process



AIRWORTHINESS REQUIREMENTS

Cargo liners must comply with Title 14 of the Code of Federal Regulations (CFR), Part 25, Subpart D, ensuring fire and smoke containment to protect passengers and crew.

Key sections include:

Section 25.857: Classifies cargo compartments by aircraft configuration.

Section 25.855: Specifies flammability requirements, tested per Appendix F, Parts One and Three.

CARGO LINER FUNCTIONS

The primary role of cargo liners is to prevent cargo bay fire and smoke from spreading to the passenger compartment, thereby allowing pilots time to activate fire suppression systems, lower the aircraft altitude, and land safely.

- **Fire Containment:** Blocks fire spread until suppression and extinguishing systems activate.
- **Environmental Seal:** Prevents hazardous smoke, or fire suppression agents from reaching occupied areas while maintaining suppression agent concentration.
- **Equipment Protection:** Shields compartment equipment from cargo-related damage to preserve the sealed environment.

CARGO LINER INSTALLATIONS

FRP liners are installed on sidewalls, ceilings, and partition walls, attached to the airframe with seams sealed by cargo tape to ensure an airtight environment. Damage like punctures or wear at attachment points compromises this seal, violating FAR 25.855, which mandates liners be separate from (but attachable to) the structure for compartments B through F. Designs vary for bulk versus containerized cargo, addressing conditions like cargo type, cycles, loading systems, and climate.

The FAA classifies aircraft cargo compartments based on their fire protection features, accessibility, and intended use.

FEATURE	Class B	Class C	Class D (Largely Phased Out)	Class E (Cargo Aircraft Only)	Class F (Newer, Accessible Main Deck)
ACCESSIBILITY IN FLIGHT	Yes, for crewmember with hand extinguisher (no entry into compartment)	No	No	No	Yes, for crewmember with hand extinguisher (no entry into compartment)
FIRE/SMOKE DETECTION	Required	Required	Not Required (relied on oxygen starvation)	Required	Required
FIRE EXTINGUISHMENT	Hand fire extinguisher by crewmember	Built-in, cockpit-controllable suppression system (e.g., Halon)	None (relied on oxygen deprivation)	None Required	Means to extinguish/control fire without crew entry (can include built-in systems, FCCs, FRCs)
VENTILATION CONTROL	Means to prevent hazardous smoke/flames entering occupied areas when access is used	Required (to aid extinguishing agent effectiveness)	Required (to limit oxygen supply)	Required (to shut off airflow)	Required (to aid extinguishing agent effectiveness)
LINER REQUIREMENTS	Must meet flame penetration standards (e.g., Appx F, Part I)	Must meet rigorous flame penetration & fire integrity standards (e.g., Appx F, Part III)	Airtight design to restrict oxygen supply	Must protect critical systems from fire damage	Must meet flame penetration standards (e.g., Appx F, Part III) if installed
TYPICAL LOCATION/USE	Main deck, smaller compartments	Inaccessible, typically lower lobes of passenger aircraft	Older aircraft, largely replaced by Class C/E for passenger use	Main deck compartments on all-cargo aircraft (freighters)	Main deck, accessible compartments, often in "combi" aircraft

Class B through F Compartments, as defined by FAR 25.857, must have liner that is separate from, but may be attached to the aircraft structure.

For more information, please visit **www.faa.gov**.

KEY CHARACTERISTICS
of Cargo Liner Design

FRP cargo liners are evaluated for fire and smoke containment, durability, and performance under in-service conditions, alongside cost and weight.

Design criteria include:

- Impact/Puncture Resistance
- Edge Bearing
- Abrasion Resistance
- Flexural Strength (lower sidewall applications)
- Flammability, Smoke and Toxicity (FST)
- Weight
- Cost

FIRE
Minimize the intensity and spread of a fire.

SMOKE
Minimize the amount the amount of smoke particles generated.

TOXICITY
Minimize the quantity of harmful gases emitted during a fire.

Bulk Cargo Compartment

Containerized Cargo Compartment

KEY PROPERTIES
by Reinforcement Type:

Mechanical strength depends on reinforcement type, style, and amount, with higher glass-to-resin ratios increasing strength. Common reinforcements include:

FEATURE/TYPE	E-Glass	S-Glass	Hybrid (E/S Glass)
ORIGIN/ DEVELOPMENT	1930s, as an electrical insulator	1960s, military/ aerospace	E-glass/S-glass combination
COST	Low	Premium	Balanced cost/ performance
MECHANICAL PROPERTIES	Good	~40% higher tensile, 20% higher modulus, 10% stiffer	Higher impact/edge-bearing than E-glass
STRENTH-TO-WEIGHT RATIO	Lower	Higher	Improved
BENEFITS/USE CASES	Cost-effective	High strength, low weight	Balances cost and performance

KEY TAKEAWAYS

- S-glass provides superior strength-to-weight for enhanced durability.
- Hybrids optimize cost, strength, and weight for fire containment and performance.

RESIN MIX & PREPREG

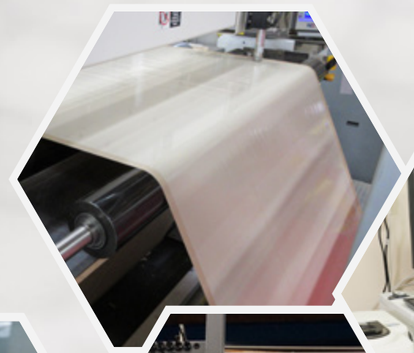
Proprietary resin formulations ensure fire safety, durability, and performance.

Base resins include:

Polyester: Standard for some aircraft (e.g., Boeing 737).

Vinyl Ester, Phenolic, Epoxy: High-performance options for fire resistance and durability.

Polyfurfuryl Alcohol (PFA): A bio-based, renewable resin from biomass waste, offering high thermal stability, flame retardancy, low smoke/toxicity, and compatibility with E-glass, S-glass, or hybrid reinforcements. PFA enhances durability and performance while reducing environmental impact. Resin chemistry, additives (e.g., flame retardants), and prepreg processes are controlled, with analytical testing ensuring seamless integration.

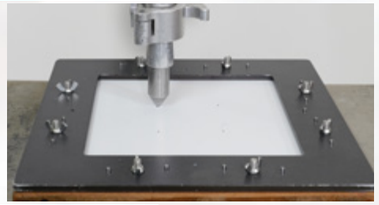


TESTING

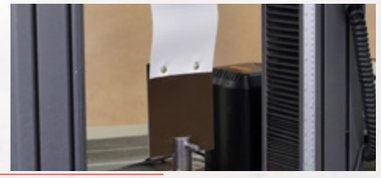
Testing exceeds aerospace standards to ensure fire and smoke containment and durability:

Flame Penetration: 30-second Bunsen burner and oil burner tests (FAR 25.855 Appendix F, Part Three) at >1600°F (871°C) for five minutes, critical for ceiling liners.

Impact: Assesses puncture resistance to maintain seal integrity.



Edge Bearing Strength: Tests attachment point durability; tear-out compromises fire containment.



General Laminate: Tensile/flexural strength and modulus for stiffness and bending resistance.

Abrasion Resistance: Simulates cargo motion wear, exceeding OEM specs for realistic performance.

For detailed testing information, please refer to The Doorway's "Laminate Testing" issue on our website at **thegillcorp.com/doorway**.

CARGO LINER GENERATIONS

FRP cargo liners have evolved to enhance fire safety, durability, and performance:

GENERATION	Key Materials and Features	Advancements
1ST (1950s-1970s)	E-glass with polyester resins	Introduced FRP liners in 1952 for basic fire containment; limited durability.
2ND (1980s-2000s)	S-glass, phenolic resins	Improved tensile strength and impact resistance for better containment and durability.
3RD (2010s-PRESENT)	Hybrid E/S-glass, aramid veils	Enhanced FST, abrasion resistance, and performance; used in modern freighters.
NEXT (2025+)	PFA bio-resins with E/S-glass or future bio-fibers	15%+ lighter, low smoke/toxicity, sustainable; improves fire containment, durability, and performance while meeting e-commerce demands and environmental regulations. PFA liners ensure superior fire/smoke containment with a reduced ecological footprint.

This evolution aligns with FAA fire safety advancements, including oil burner testing since the 1990s.

CERTIFICATIONS AND SPECIFIC PRODUCTS

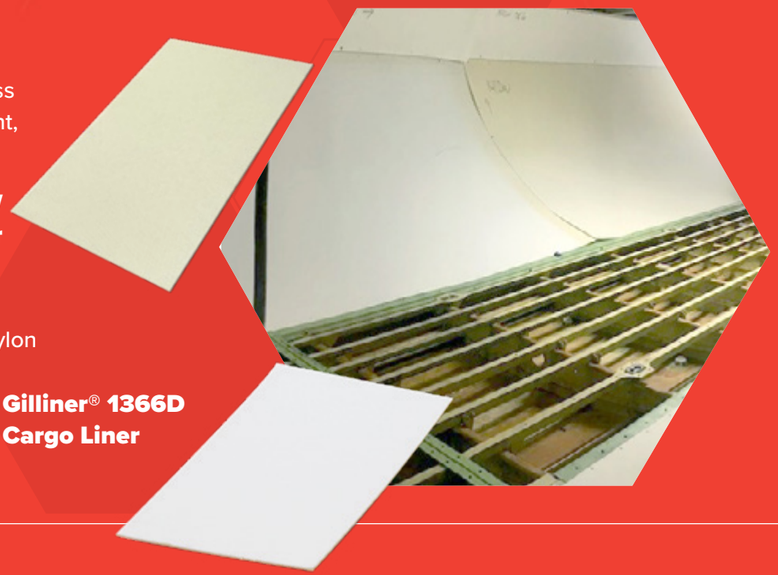
Maintenance, Repair, and Overhaul (MRO) solutions are provided under FAA Parts Manufacturer Approval (PMA), European Parts Approval (EPA), and Owner/Operator Produced Parts (OOPP), offering cost-effective, airworthy FRP liners.

PMA /EPA

Gilliner® 1366W (PMA approved): E/S-glass with aramid veil; optimizes strength, weight, and abrasion resistance for superior performance.

OOPP

Gilliner® 1366D (OOPP-approved): E-glass/S-glass with polyester resin and nylon scrim; durable and efficient.



Gilliner® 1366W Cargo Liner

Gilliner® 1366D Cargo Liner

STC

PASSENGER TO FREIGHTER (P2F) CONVERSIONS

E-commerce growth drives passenger-to-freighter conversions. FRP liners, including PFA-based options, replace sidewalls and ceilings with precision machining for fit. Supplemental Type Certificates (STCs) are supported for modifications, ensuring fire safety, durability, and performance.

Saab 2000 photos courtesy of Taby Air Maintenance (TAM)

Since pioneering FRP cargo liners in 1952, TGC's continuous investments in R&D and vertical integration have developed solutions that prioritize fire and smoke containment, durability, performance that enable safe aircraft operation during emergencies while minimizing overall costs. TGC's new sustainable PFA resins, paired with advanced reinforcements enhance these attributes while reducing environmental impact.

For a list of qualified OEM specifications, please visit **www.thegillcorp.com**.

Fun Facts

Nepal has the most mathematical flag in the world. It even has an article in its constitution that details the steps of drawing the flag.

Mount Rushmore cost less than one million dollars to construct. It took 14 years to build – from 1927 to 1941 and took 400 workers.

Samsung means "three stars" in Korean. This was chosen by the founder because he wanted the company to be powerful and everlasting, like stars in the sky.

While shedding, geckos will eat their skin in order to prevent predators from finding and eating them more easily.

Bees actually have knees. The expression comes from the fact that they store large build-ups of pollen in hairy baskets on their knees.

Between North and South Korea lies 155 miles of no man's land, where hundreds of rare animal species thrive.

While watching a Merry-Go-Round from a bench in Griffith Park, Los Angeles, Walt Disney was struck with inspiration for the creation of Disneyland.

There is a Scottish tartan designed for Mars exploration. It was officially registered in 2016 to be worn during Mars science, exploration, and outreach activities.

Santa Claus was issued a pilot's license by the U.S. government in 1927. They also gave him airway maps and promised to keep the runway lights on.

When you exercise, the burned fat metabolizes to become carbon dioxide, water, and energy. Meaning that you exhale the fat that you lose.

Polar bears often hunt walruses by simply charging at a group of them and eating the ones that were crushed or wounded in the mass panic to escape. Direct attacks are rare.

The word "velociraptor" comes from the Latin words "velox" which means swift, and "raptor," which means robber. Literally – speedy robber!

The group of spikes at the end of stegosaurid tails is called the "thagomizer." They had no distinct name until the term was coined in 1982 by a cartoonist.

There is a correlation between pulling an all-nighter and snapping out of depression. This is because the brain gets more active the longer it goes without sleep.

Adult cats only meow at humans, not other cats. Kittens meow to their mother, but once they get a little older, cats no longer meow to other cats.

When shuffling a deck of cards, the number of possible arrangements is approximately 8×1067. That's more than the number of stars in the observable universe.

THE GILL CORPORATION

The Gill Corporation
International Headquarters
4056 Easy Street
El Monte, California 91731 USA
Phone: +1 626 443-6094
Email: info@thegillcorp.com

The Gill Corporation – Maryland
1502 Quarry Drive
Edgewood, Maryland 21040 USA
Phone: +1 410 676-7100
Email: info@thegillcorp.com

The Gill Corporation – France
Route de l'Aviation
7 Allée Etchecopar
64600 Anglet France
Phone: +33 (0) 5 59 41 25 25
Email: info@thegillcorp.com

The Gill Corporation – Europe
23 Enterprise Road
Bangor, Co-Down BT19 7TA
Northern Ireland, United Kingdom
Phone: +44 (0) 2891 470073
Email: info@thegillcorp.com

www.thegillcorp.com