



The Composite Aircraft Propeller Revolution:

Hartzell's Advanced Carbon Fiber Propeller Blade Technology

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With a history dating back to the Wright Brothers, Hartzell Propeller has long been at the forefront of aviation propeller technology. As aircraft have become increasingly more complex – and with the emergence of Advanced Air Mobility (AAM) and electric/hybrid flight – Hartzell has continued to lead the industry with innovative structural carbon fiber composite propeller blades utilizing state-of-the-art materials and cutting-edge engineering and manufacturing processes.

The Evolution of Hartzell's Composite Blades

Hartzell introduced propeller blades made from "Hartzite," a fiber reinforced phenolic composite, in 1944. These propellers were installed on the Republic Seabee, North American Navion, as well as others.

In 1978, Hartzell Propeller produced the first type-certificated primary structure composite propeller blade, a true monocoque design with compression-molded Kevlar®/epoxy over a foam core. First certificated on the CASA 212 aircraft, Hartzell's early composite blade technology represented an industry breakthrough that would shape the future of aircraft propulsion.

The CASA 212 blade was the first in what is now referred to as the Hartzell "Legacy" composite blade family. There are sixteen different "Legacy" unique aerodynamic designs, utilized on 24 different type certificated installations, including the Beech 1900C and D, Shorts SD3-60, Dornier Do328, and Pilatus PC-21. The Legacy line is still in production with over 20,000 blades produced. Many of the original CASA 212 blades are still in service with over 50,000 hours TSN. In the 1990s, carbon/epoxy laminate was introduced into the legacy family. The addition of carbon increased the capabilities of the design allowing composite blades on more demanding installations. The carbon designs are also in production for large hovercraft.



*Hartzell "Hartzite"
Propeller Blade*

Next-Generation Carbon Fiber Technology: ASC-II

As early composite propellers were slowly adopted across the aerospace and defense industries, it became apparent that improvements were needed to reduce the high cost of the manufacturing process. Hartzell Propeller's technical team rose to the challenge, refining the materials and manufacturing techniques to produce more cost-effective composite blades.

In 2006, Hartzell introduced the second generation Advanced Structural Composite propeller blade (ASC-II), utilizing a resin transfer molding process and aerospace-grade carbon fiber composite materials.

The ASC-II blade consists of a unique monocoque structure of carbon fiber laminates over a low-density synthetic core and integrated into a co-molded stainless steel shank. The leading edge outboard of the de-ice boot is protected with a co-molded electroformed nickel erosion shield to mitigate water and foreign object damage (FOD). In addition to enduring grueling fatigue loads, the blades are designed and tested to withstand direct lightning effects. Lightning tests are also performed on de-iced propellers to assure the aircraft system is protected from indirect lightning effects. Each and every new blade design is impact tested to demonstrate the ability to tolerate bird strikes.

Hartzell's innovative ASC-II technology was launched with the Cirrus SR-22T and has since been used on 35 different blade part numbers, 19 different propeller type certificates, and 30 different Aircraft Type Certificates. To date, more than 45,000 (and counting) ASC-II composite propeller blades have been produced using advanced carbon fiber materials and proprietary manufacturing processes.



ASC-II Carbon
Fiber Propeller

Hartzell's Carbon Fiber Technology



High-voltage lightning strike testing

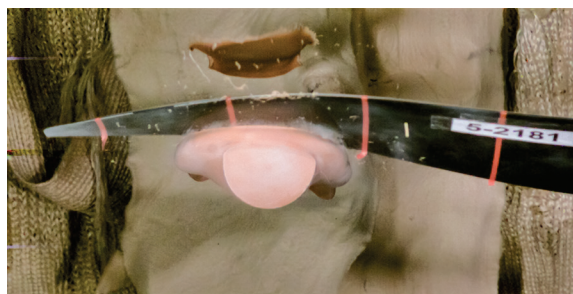


High current lightning strike testing

20
LIGHTNING TEST
QUALIFICATIONS



Bird strike testing with 4-lbs weight



Real bird strike - prop remains airworthy

200+
BIRD IMPACT TESTS

BLADES WITH
50,000+ FLIGHT HOURS
STILL FLYING TODAY

DEDICATED COMPOSITE DESIGN, MANUFACTURING AND SERVICES TEAM

Materials Matter: Aerospace-Grade Carbon Fiber vs. Wood Core

Not all "composite" propeller blades are made the same. Unlike some propellers on the market, Hartzell Propeller's carbon fiber composite blades are designed using modern aerospace materials — structural carbon fiber over urethane synthetic cores — not thin environmental layers of composite over a wood core.

Better Materials for Better Performance

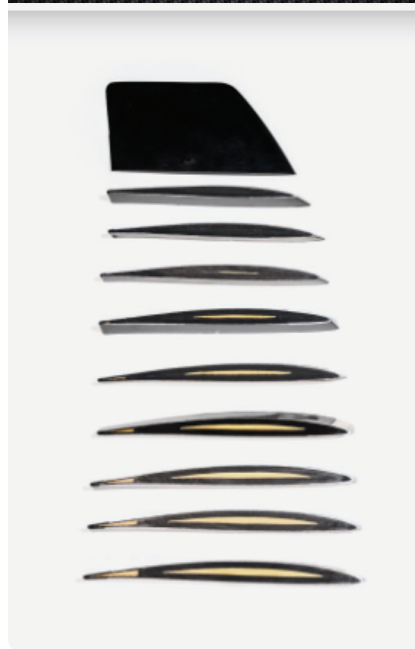
Utilizing braided carbon fiber materials enables Hartzell to provide optimized propellers for its customers while still meeting stringent strength and durability requirements. The carbon fiber Hartzell utilizes is 10 times stronger than spruce and 5 times stronger than the beech wood cores selected by other manufacturers' wood cores designs. This strength advantage enables Hartzell engineers to build stronger, more efficient propellers than other propeller manufacturers.

Aerodynamic Design

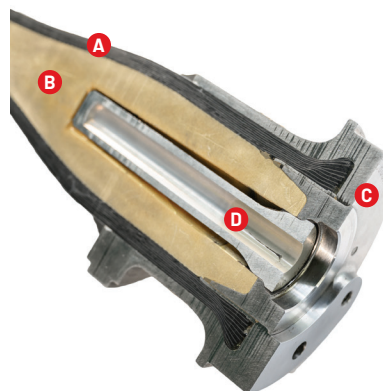
Carbon fiber blades are significantly thinner than laminated wood blades, producing less drag as a result. Hartzell's advanced carbon fiber materials enable wider, thinner airfoils that can still bear the structural load required for optimum aircraft operations and also allow for popular designs like the swept-tip scimitar blade.

In this way, Hartzell's aerodynamic carbon fiber blades can yield more thrust and deliver better acceleration and climb performance.

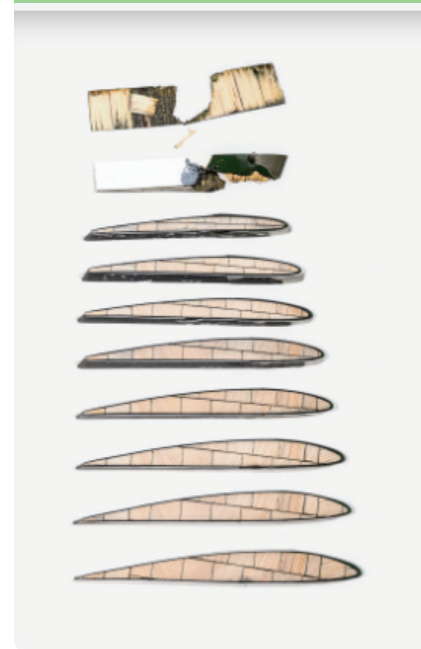
Hartzell Carbon Fiber Composite



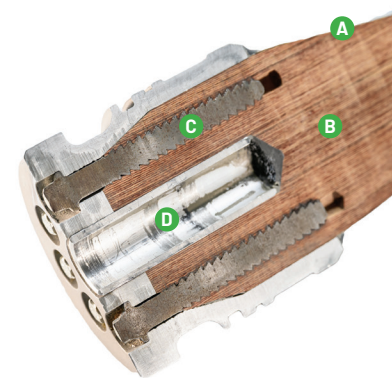
- A - Structural Carbon Fiber
- B - Synthetic Core
- C - 360° Retention Wedge
- D - Balance Tube



Natural Composite Wood Core



- A - Composite Exterior Coating
- B - Laminated Wood Core
- C - Lag Screws
- D - Balance Tube



Weight Savings

When compared to aluminum propellers, Hartzell's carbon fiber props offer superior strength, damage resistance, and significant weight reduction. Due to the lower weight and corresponding lower moment of inertia, carbon fiber blade propellers can also enable a higher blade count, which can enhance performance across all flight spectrums, especially for higher-horsepower aircraft.

Durability

Hartzell's carbon fiber propeller blades are engineered to be strong and impact-resistant, making them ideal for off-airport, backcountry operations. In particular, the wedge retention system and stainless steel shanks are much more durable than the alternative aluminum/lag bolt design.

Moisture Absorption

Wood core propellers are very susceptible to moisture absorption which can lead to imbalance and a significant reduction in the strength of the wood. This is why some wood core blades are required to be returned to the factory in the event the protective covering is worn or damaged to the point where the wood is exposed.



Carbon fiber blade with repairable bird strike damage



Wood composite irreparable tie down rope damage

Ease of Repairability

Adding to the value is the maintenance advantage offered by Hartzell's carbon fiber propeller blades. Very often, minor nicks, scratches, and dings on Hartzell carbon fiber blades actually meet the criteria for airworthy damage. This allows for continued flight until minor repairs can be accomplished on-wing by an A&P or a repairman in a part 145 shop using commonly-available tools and kits available from Hartzell.

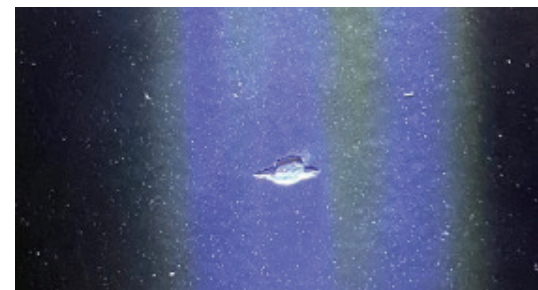
When major repairs or factory-only repairs are required, Hartzell's carbon fiber blades can be restored to factory-new condition, enabling a significant increase in usable life over metal or wood core blades. In fact, Hartzell structural carbon fiber blades are certified for unlimited life and can be repaired in the field or at an authorized propeller service facility. For owners and operators seeking the highest level of quality, service, and support, Hartzell Global Services provides a premier network of Hartzell-owned and factory-backed MRO facilities.

Hartzell Global Services

Hartzell Global Services supports operators worldwide through a network of factory-owned facilities and authorized service centers. From routine maintenance and overhauls to advanced blade repairs, operators have access to OEM expertise and responsive support designed to minimize downtime and keep aircraft flying.



*Examples of airworthy damage
to Hartzell carbon fiber blades*



Making the Switch: A Closer Look at Carbon Fiber Propeller Conversions

Carbon fiber propellers are the fastest-growing segment of propeller technology today due to the advantages they offer in terms of weight savings, performance benefits, and superior strength and durability.

As a result, many aircraft manufacturers now select carbon fiber composite props as standard equipment on their airplanes, and thousands of aircraft owners and operators have elected to upgrade from aluminum propellers to the newest carbon fiber blades through Hartzell's Top Prop STC Propeller Conversion Program. Furthermore, several companies that offer engine conversions or modifications collaborate with Hartzell to have a Top Prop propeller approved with their engine modification STC.

The Path to Certification

Hartzell's Quality Management System is FAA-approved and AS9100C certified to maintain the highest quality and safety standards throughout the design, engineering, manufacturing, and testing processes.

Hartzell propellers for type-certificated aircraft meet the rigorous safety, performance, and airworthiness standards set forth by regulatory bodies. All certificated propellers have shown compliance to Code of Federal Regulations Title 14, Part 35, "Airworthiness Standards: Propellers." Subsequent foreign certifications are validated by the civil aviation authority of each country.

Propellers for Experimental Installations

Hartzell applies the same high quality and strength standards to propellers for the experimental market as those for the certificated market.



Inside Hartzell's Flight Testing Process

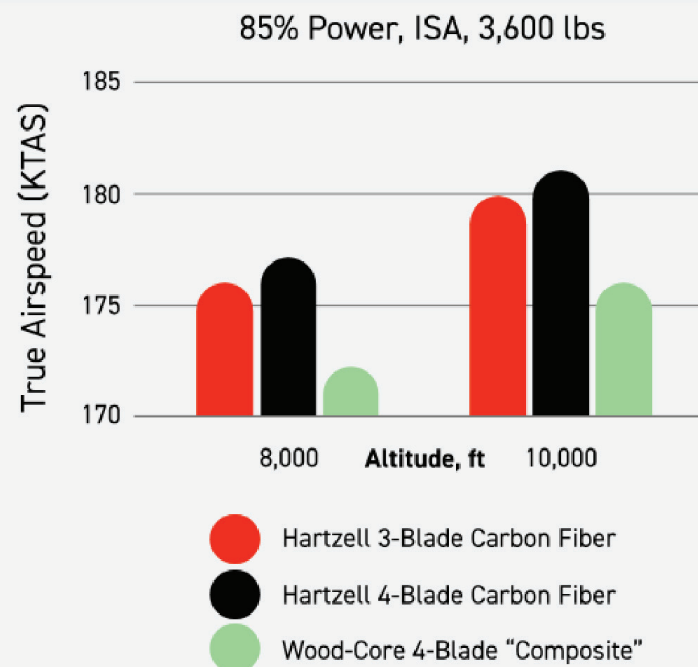
With a dedicated team of certification experts and an Organization Designation Authorization (ODA) from the FAA, Hartzell has successfully navigated the meticulous certification process to produce hundreds of airworthy certified propellers.

As an example, for a recent 4-blade carbon fiber composite STC, Hartzell flight tested three different Cirrus SR22T aircraft for nearly 100 flight hours in total. The meticulous testing process compared several different propeller models, including the airplane's stock 3-blade Hartzell carbon fiber baseline, a new 4-blade Hartzell carbon fiber design, and a competitor's 4-blade wood core STC.

The new Hartzell 4-blade carbon fiber propeller outperformed the other propellers in several key areas of flight, including 5% better climb performance, noise reduction of 2 dB(A), and, most significantly, 4 KTAS faster when compared to the other 4-blade propeller under identical flight conditions.

By flight testing in real-world conditions, Hartzell ensures its carbon fiber propellers are optimized for safety, reliability, and efficiency in every scenario and phase of flight.

CIRRUS SR22T CRUISE PERFORMANCE



Why Pilots Love the Hartzell Advantage



"Every takeoff, every climb, every flight – my Hartzell prop performs flawlessly. It's the only propeller I want on my Cirrus."

- MIKE GOULIAN



"I was able to swap out my old small two-blade prop for the Carbon Voyager and not change the center of gravity or the weight of my airplane at all. This prop is providing so much more thrust and getting me in and out of places a lot better than my old setup."

- ESSEX PRESCOTT



"What's really surprised me about the Pathfinder carbon fiber propeller is its consistency. And even after flying into a few rougher areas, it still looks brand new, which says a lot about how durable it really is."

- ANNIE VOGEL



"We found a dramatic difference between aluminum propellers, which we had flown for years, and the Hartzell carbon fiber composite propellers. All around, there was a better performance, not to mention it was a much smoother ride."

- KEN RIEDER

Propelling the Future of Flight: Carbon Fiber Propeller Solutions for Advanced Air Mobility

With decades of experience in the design and manufacturing of structural carbon fiber blades, Hartzell Propeller is still innovating and optimizing its processes, leveraging sophisticated engineering analytics and flight testing capabilities to design better airfoils for next-generation aircraft.

Since 2019, Hartzell has dedicated tens of thousands of engineering and development hours to electric, hybrid, and hydrogen powered aircraft, with several prominent programs underway. Hartzell's advanced carbon fiber propellers have already proven critical to groundbreaking AAM platforms, including BETA Technologies' all-electric Alia VTOL and CTOL aircraft. Hartzell has also partnered with leading electric motor manufacturer magniX, providing lightweight carbon fiber propellers optimized for cutting-edge electric propulsion systems. This innovative platform powers Harbor Air's revolutionary eBeaver seaplane retrofit, which made history as the world's first fully electric commercial aircraft to take flight.

The innovative blend of sophisticated engineering analytics, certification skills, and world-class manufacturing technologies continues to make Hartzell Propeller the global leader in propeller design and manufacturing — and an ideal partner for AAM programs seeking custom propulsion solutions.



Harbor Air's eBeaver Powered by MagniX



BETA Technologies' Alia



EXPERIENCE THE
**HARTZELL
ADVANTAGE**

TRUE CARBON FIBER PERFORMANCE

Don't settle for anything less than the best for your dream airplane. Contact us to learn more about carbon fiber propeller upgrade options for your aircraft through our Top Prop conversion program.

