

Composite Slit Tape Processing:

A Critical Link in the Aerospace Supply Chain

WHY TECHNICAL PRECISION MATTERS

GAME CHANGER: THE NEW ERA OF THE COMPOSITE AIRPLANE

When the sleek new Boeing 787 Dreamliner took off on its maiden flight from Paine Field in Everett, Washington on December 15, 2009 at exactly 10:27 a.m. Pacific time, it opened a new era in aviation history. The 20th century's metal jetliner finally gave way to the 21st century's "Composite Airplane."

The initial success of the Boeing 787 capped two decades of increasing use of carbon-reinforced plastic in commercial and military aircraft, signaling a bright future for innovative composite applications in the aerospace industry.¹

The Dreamliner represents a major leap forward in aviation engineering, design, and manufacturing innovation. Composite material comprises about 50 percent of the 787's structural weight, compared to 10 to 20 percent in the typical commercial airline jet.² Due to a combination of less weight and more efficient engines, the Dreamliner promises to burn up to 20 percent less fuel and reduce greenhouse gas emissions over previous models.³

Battered by increasing fuel costs and the deepest recession in decades, many airlines have warmly embraced the Dreamliner by placing a record number of orders. As one airline executive put it, "[the 787] has the potential to be a game changer for our industry, both in reducing our costs and our environmental footprint."⁴

A game changer, indeed.



NEW OPPORTUNITIES, NEW CHALLENGES, AND NEW INNOVATIONS

Unlike metal, composites never corrode and are more fatigue-resistant. Fueled in large part by the production of lightweight, fuel-efficient, and high-performance aircraft such as the 787 and the Airbus A350XWB, the aerospace industry's demand for composites is expected to more than double between 2007 and 2014.⁵

The Dreamliner is allowing aerospace engineers and designers to prove the potential benefits of composite aircraft such as lower maintenance costs, enhanced strength, corrosion resistance, fuel efficiency, and a better passenger experience. As an example, engineers are able to design aircraft to supply fresher, more humid air to a higher-pressurized cabin. As a result, passengers experience a reduced level of altitude inside the aircraft and a healthier, more comfortable ride.⁶

For all the benefits of these lightweight and fuel-efficient composite aircraft, the aircraft structures themselves are typically more complex to make than their metal counterparts and far harder to inspect for flaws. But the potential benefits are strong enough that innovations in manufacturing, quality, and inspection have been developed to make the use of composites in aircraft construction feasible and cost-effective.



One of these major innovations in composite aircraft manufacturing is an extraordinarily precise process that can transform carbon fiber pre-impregnated with epoxy resins (known as *UD prepreg*) into finished precision composite slit tape. The breakthroughs in technology to produce precision composite slit tape are revolutionizing the way in which airplanes like the 787 and A350XWB are built. This layered composite slit tape is the essential material used in the automated fiber placement (AFP) manufacturing process to build the actual airframe structure and its component parts.

Full-size primary components for the 787 are assembled in one piece from this precision composite slit tape, yielding fewer holes and weak points in the structure. Airbus builds the A350XWB in panels made from precision composite slit tape which become fastened together over a framework. The U.S. Department of Defense's F35 Joint Strike Fighter program also utilizes fiber placement technology and precision composite slit tape for certain primary structures such as wing skins.⁷

So while materials such as precision composite slit tape are transforming aircraft manufacturing, they are also introducing new complexities and challenges for quality and precision that must be managed across the supply chain. And if the focus on composite slit tape falls in priority or lacks adequate resources within an organization, costly failures can multiply and spread rapidly across the supply chain, resulting in production delays or quality issues. Sourcing quality composite slit tape is crucial to each partner for successful part manufacturing in this multi-stage process.

WHY TECHNICAL PRECISION MATTERS

Few industries are as obsessed with quality and precision as the aerospace industry. Aerospace industry manufacturing processes and systems must be controlled, consistent, predictable, measurable, and sustainable over multi-year production programs — and for good reason. Even apparently minor defects in the structure of aircraft may have far-reaching consequences.

With the new Boeing 787 now in the air, and the Airbus A350 expected within three years, composite airplanes are fast becoming a reality for the flying public. Manufacturing primary structures from composites has been well-tested in various smaller parts before, but not on the scale of the current projects for each aircraft maker. Aircraft part design, material characteristics, automated material lay-up, finished-part testing, and flight certification all demand a strict adherence to a new set of standards, and should be expected to change as standards evolve and as learning and feedback from all these efforts are rolled up into process improvements for high-volume manufacturing of these new planes.



In all of this work, precision standards are being set for composite products that get used in the production of the aircraft part and must be maintained consistently to ensure flight performance and safety. Today, the market is ready to commit passengers and crew to thousands of flight hours and expects 20 to 30 years of flawless performance from these new airplanes. When it comes to making airplanes from composites, meeting these standards is the only acceptable choice.

Therefore, quality management is paramount when it comes to precision composite slit tape production. This complex and technically exacting process demands the highest levels of expertise and quality controls to transform master rolls of carbon prepreg into aerospace-grade UD prepreg slit tape that will feed the tape-laying head on the aircraft part assembly line.

The remainder of this eBook will explore seven key precision elements for producing precision composite slit tape and why they are critically important for achieving the best performance from today's demanding composite aerospace applications. We will also discuss the implications to the supply chain for ensuring the production and application of the highest-quality precision composite slit tape in the fiber placement process for this new era of aircraft manufacturing.



PRECISION ELEMENT #1: EXACTING SPECIFICATIONS

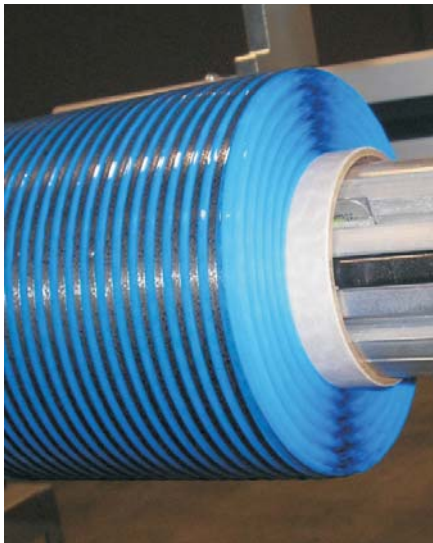
Sitting at the top of the aerospace “food chain,” aircraft manufacturers establish and enforce the vast majority of design, performance and production specifications governing all downstream supply chain activities, including precision composite slit tape processing. At the risk of stating the obvious, these specifications and standards are critical and are one of the key ways that aircraft manufacturers and their suppliers keep score of how they're doing with quality.

Before specifications even come into play, suppliers must undergo an intensive certification process over many months to ensure compliance with process control standards and specifications for the construction and assembly of aircraft. Once certified, material suppliers – and their partners like Web Industries – must meticulously manage and comply with rigorous specifications and process controls to drive the consistent production of high-performance spools of precision composite slit tape.

Let's face it, specifications set the bar for quality precision composite slit tape processing. Set the bar beyond realistic reach, and you may risk unacceptable production delays. Set the bar too low and quality may suffer. Achieving the right balance is critical because these specifications are what drive the downstream and upstream flow of materials, parts, and manufacturing processes across the aerospace supply chain.

PRECISION ELEMENT #2: METICULOUS MATERIAL MANAGEMENT

Like any packaged good or produce bought at the supermarket, UD prepreg has a limited shelf life. Managing the material's shelf life requires strict quality controls in order to ensure full utilization and production of aerospace-qualified precision composite slit tape.



From the time the master rolls of prepreg material are made until the finished precision composite slit tape are shipped to the fabricator, the process *and processor* must thoroughly capture and analyze data about every variable in the controlled environment and every step in this exacting process.

For example, master rolls of prepreg arrive at the precision composite slit tape processing facility in a solid, frozen state of approximately 14 degrees Fahrenheit, a temperature that helps retard curing of the resin. For this reason, the slit tape processor must closely track the raw and finished material's exposure to room temperature. If the prepreg or resulting slit tape is handled improperly by those not certified or qualified in aerospace standards – like simply allowing the material to thaw for too long – it can become useless.

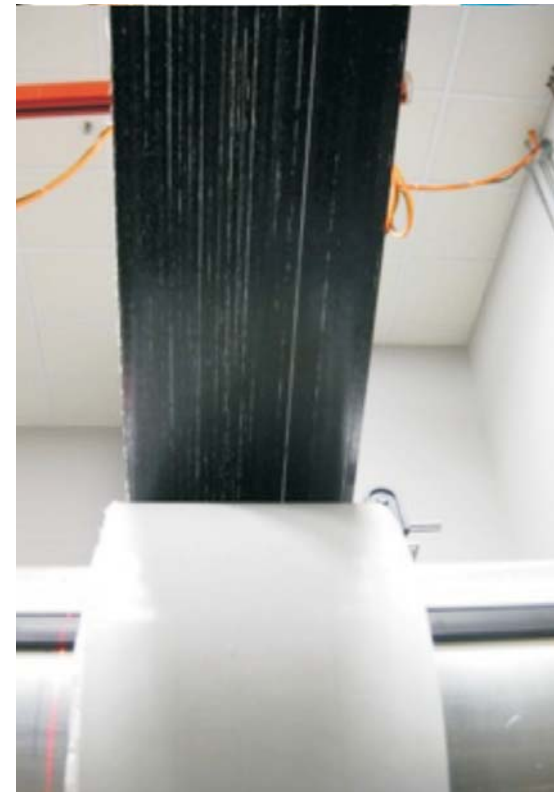
PRECISION ELEMENT #3: RIGOROUS QUALITY MANAGEMENT

Once the process controls are in place and the incoming master rolls of UD prepreg come up to room temperature, they can be processed, slit and wound onto spools, becoming precision composite slit tape. During this process, the slit tape processor must take pains to remove obvious or identified flaws from the incoming prepreg master rolls before proceeding with the production process. Typical flaws include gaps or stringers, layering, dry spots in the web, and excessive or insufficient tack.⁸

As the final link in the supply chain, the composite slit tape process should fit into the fabricator's process, as well as preserve and improve the manufactured prepreg's performance, format, and logistical characteristics. Since slitting, liner insertion, and spooling are the final steps in making prepreg tape, it is absolutely critical that the process remove any marked defects and prevent them from making it into the resulting slit tape and into the part made from it.

If the process is not well-controlled, accountable, and sophisticated enough to meet downstream requirements, defects and unacceptable inconsistencies in material properties can ultimately slip through, impacting process performance and finished aircraft part integrity, reflecting poorly on the prepreg manufacturer's brand.

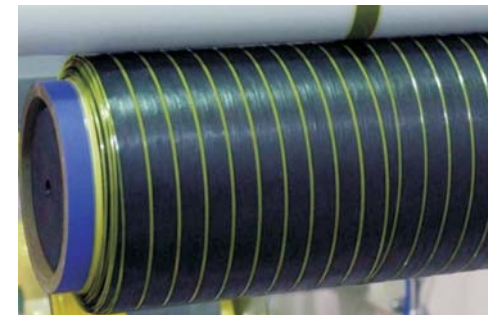
Experienced processors focusing on this aspect of the business every day are far more likely to identify and eliminate problem material before it reaches the supply chain, reducing the need for aircraft part fabricators to make costly and time-consuming post-production repairs, while assuring higher satisfaction with finished parts.



PRECISION ELEMENT #4: COMPLETE LOT TRACEABILITY

Aircraft part fabricators will often consume large volumes of composite slit tape in making a specific part. In the event that a material defect or inconsistency is identified, it will automatically trigger an investigation to track down the batch or lot of material and the underlying source of the problem. How and why did a given lot of material end up less sticky or drier than it should be? Was it an unusual circumstance, a change in a machine setting, a new operator, or a new shipment of component material that caused the variation in material from one spool to another?

Complete lot traceability is absolutely essential to managing quality throughout this complex end-to-end process. Experienced processors can identify the root of any processing or material problem. Often, they can implement corrective measures before the finished spools enter the supply stream when they are delivered to the part fabricator.



PRECISION ELEMENT #5: STRICT TOLERANCES

Precision composite tape is slit according to exact specifications. The width of the tape must be extremely accurate, consistent and fall within strict tolerances. Typically, these variances must not exceed ± 0.005 inch as measured from edge to edge of the tape, while sometimes they are set even higher to no more than ± 0.003 in.

These specifications are crucial. Too much variation in slit width within a given spool can create air pockets between tapes, known as voids, when the tapes are laid down side by side, producing unacceptable weaknesses in the resulting aircraft part.²

PRECISION ELEMENT #6: PROCESS CONTROL AND THE TEST BED

The entire processing of precision composite slit tape itself also provides a test bed for ensuring a consistently high-quality fabrication process. If the UD prepreg passes through the slitting and winding process smoothly, chances are it is going to unwind and travel through the automated part fabrication process smoothly as well.

For example, if the material is too sticky, it will likely stick to the producer's rollers and blades and won't wind properly. If the material is too dry, it will create fuzzy edges, gaps or splits in the material and won't hold tolerances well. It also may not hold a splice between one master roll to another to build the spool.

These slit tape production challenges illustrate that the exacting process of making aerospace-grade UD prepreg slit tape requires far more than merely installing and operating a slitting and winding machine. Composite prepreg is a complex and organic material due largely to its carefully engineered mix of fibers and uncured resins. As a result, successful processing requires experienced control of many variables to dial in the optimum conditions for each particular material type.



PRECISION ELEMENT #7: OPTIMAL PROCESSING ENVIRONMENT AND CORE COMPETENCIES

There are several key elements of a precision composite slit tape processing environment that must be in place. Anything less could introduce significant risk into the supply chain. The key elements include:

- Class 100K clean room or better
- Temperature and humidity-controlled environments
- Refrigerated storage with redundant power supplies
- Quality and inspection systems
- Continuous slit-width measurements and verification
- Documentation and complete process control
- Automated splicing systems
- Dedicated aerospace-qualified materials and processing engineers
- Open-architecture information systems for supply chain integration
- Material tracking systems and comprehensive lot traceability
- Specialized packaging and handling controls



All of these measures are designed to ensure the production of the finest quality and most consistent precision slit tape in order to meet the exacting standards for aerospace applications and programs.

TRUST THE EXPERTS IN COMPOSITE SLIT TAPE PROCESSING

For more than 20 years, Web Industries has worked closely with aircraft manufacturers, part fabricators, and prepreg raw material manufacturers to develop the commercial and military aerospace industry's platinum standards for precision slitting and spooling of composite slit tape. Web Industries produces precision composite slit tape that is used on all major AFP lines. We are the most trusted source for composite tape for commercial, space, and military programs.

We can produce your precision composite slit tape products faster, better, and more efficiently. The composite slit tape processing capabilities at our AS9100 and ISO-9001-2008 registered facilities are unmatched anywhere in the world in terms of quality, productivity, scale, and expertise.

As the aerospace industry's composite slit tape requirements continue to evolve, our customers depend on us to provide the depth and breadth of experience to help them develop and launch new products, qualify new programs, and produce precision composite slit tape for all aerospace applications.

Web can even provide extensive material testing, experimentation, and measurement capabilities in our new state-of-the-art development center to help you advance new research and development projects, new material development, product testing, and new program qualification.

When you source precision composite slit tape from the recognized experts at Web Industries, you can be confident that the finished product will meet or exceed the highest industry standards, day in and day out, year after year.

For more information about how Web Industries can help you achieve the premium standard in precision composite slitting and winding, contact us at +1 508.573.7979 or visit www.webindustries.com.

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³ David Parker Brown, *Why Does the Boeing 787 Matter?*, AirlineReporter.com, Dec. 16, 2009, <http://blog.seattlepi.com/airlinereporter/archives/188415.asp>

⁴ Dominic Gates, *Dreamliner makes history with plastic, outsourcing, design and delays*, *Seattle Times*, Dec. 12, 2009.

⁵ Tony Roberts, *The Carbon Fibre Industry*, Material Technology Publications (MTP), 2008, Updated June 2009.

⁶ See note 4.

⁷ Edward G. Carson, *The Changing Business Dynamics of the Global Composites Industry Outlook for 2010-2015*, GMC2 LLC, Carbon Fiber 2009 Conference Presentation, Sept. 23, 2009.



A 100% employee-owned company based outside

of Boston, Massachusetts, Web Industries is a global leader specializing in custom manufacturing and development for flexible materials for over 40 years. Web Industries applies expertise, innovative thinking and creative problem solving to help speed time to market, drive costs down, and continuously improve processes to maximize our customers' product success. Web is a critical piece of the manufacturing process for a wide range of products spanning airplane parts to baby diapers. Web serves five strategic markets including advanced composites for aerospace; medical diagnostics; consumer products; wire and cable; and emerging technologies such as thin films used in solar and flexible electronics applications. Current certifications and compliance include ISO 9001, 13485, 14001, and AS 9100. Our leadership position and ability to provide our customers with superior contract manufacturing services for flexible materials is based on a history of expertise and success, a passionate values system, and our investment in our customers by the employee-owners of Web Industries.

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