Composite materials for aircraft wing structures are increasing the need for lightning protection equipment

Suppliers must move toward advanced, reliable, and repeatable manufacturing solutions.

WHITE PAPER

Second in a series of two

Parker Aerospace

ENGINEERING YOUR SUCCESS.

Table of Contents

Introduction 2
Transformation in the manufacture of lightning protection equipment. 3
Current manufacturing challenges, methods, and future needs 5
What to look for in a lightning protection equipment supplier 8
Conclusion 10
About Parker Aerospace..... 10
Parker Aerospace on-site testing capabilities for lightning and fire 11
Parker Aerospace offers a comprehensive line of lightning and flame protection equipment 13
References 15

Introduction

As the use of composite materials for aircraft wing structures continues to grow, advanced and evolving manufacturing methods will help aircraft manufacturers build wings more quickly and cost-effectively, lowering costs for composite structures and increasing demand for the use of composites across the commercial aircraft spectrum.

Regardless of the composite construction methods and technology used, commercial aircraft wings will need to include lightning protection equipment to ensure safe flight. Unlike metal wings, composite structures do not provide a highly conductive pathway for lightning currents to transfer back into the atmosphere. Inline lightning dissipation methods are crucial to preventing ignition in the fuel tanks, fuel lines, and fuel vents while also protecting complex electrical and electronic systems from being damaged by lightning surges.

To facilitate the increased demand for lightning protection equipment, suppliers will need to implement automation strategies to meet build and cost requirements of commercial aircraft makers. The suppliers who are best able to execute these strategies and thoroughly test their equipment will arise as thought leading aircraft industry partners while supporting the need for critical lightning protection equipment.

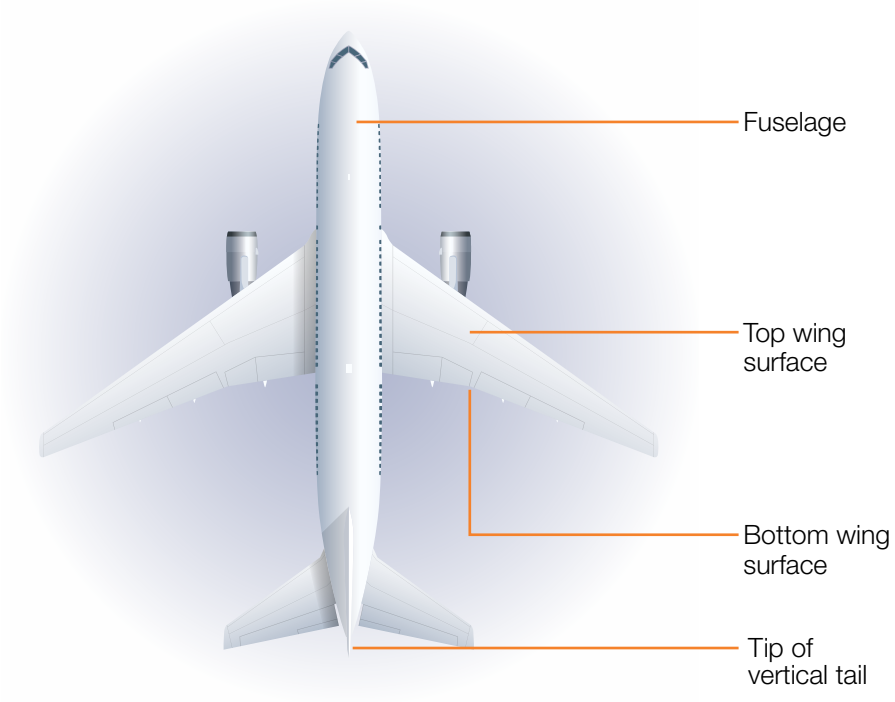
This white paper will explore:

- **Design and equipment solutions for lightning dissipation**
- **Current lightning dissipation equipment manufacturing challenges, methods, and future needs**
- **What aircraft manufacturers should look for in a lightning protection equipment supplier**

The manufacture of lightning protection equipment used in composite wings will undergo a transformation as robotics and greater automation are applied to meet growing production demands and lower cost requirements.

It is estimated that every airliner is struck by lightning in flight at least once a year and usually without passengers knowing about it at the time. Lightning attaches to entry and exit points almost simultaneously, and most commonly strikes the fuselage, top and bottom of the wing surfaces, and tip of the vertical tail. When an airliner is exposed to lightning strikes, a large amount of electrical energy is distributed over the entire surface of the aircraft. Without proper dissipation techniques, some of this energy can travel into the fuel lines, moving through the conductive pipes and arcing across the connections or other lines creating a potential fuel ignition source.

Aircraft with an aluminum fuselage and wings can readily conduct the charge from a lightning strike, allowing the current to move across the skin and pass back to the atmosphere. Composite structures, however, are significantly less conductive than aluminum, having no highly conductive pathway for a lightning current to leave the aircraft.



Aircraft with an aluminum fuselage and wings can readily conduct the charge from a lightning strike, allowing the current to move across the skin and pass back to the atmosphere. Composite structures, however, are significantly less conductive than aluminum, having no highly conductive pathway for a lightning current to leave the aircraft.

To combat this threat, aircraft designers of composite wing and fuselage structures install conductive light-weight metal mesh to a thick outer layer of fiberglass. This solution spreads the current to minimize damage to the skin where lightning attaches, creating a continuous path of low resistance over the entire aircraft exterior. This solution keeps the current away from the inner shell of carbon fiber that forms the main structures and away from the fuel/hydraulic lines.

Additional mitigation techniques are designed to prevent arcing where a section of metal, such as joints and fasteners, is connected to a carbon fiber composite. These sections, especially those located near a fuel tank, are of special concern to aircraft engineers who must find alternative paths for lightning currents while maintaining proper bonds and spacing. **Static dissipating tubes, also known as fuel and vent line isolators, play an integral role in controlling lightning's energy flow. By allowing the fuel system architecture to have a resistance value higher than the outer composite structure, isolator tubes permit limited current flow to minimize arcing and allow static dissipation.** While static dissipating tubes are of critical importance to composite aircraft, they also serve as an extra safety measure for conventional metal-designed aircraft.

The new generation of carbon fiber reinforced plastic (CFRP) materials are much more durable than the composites of 20 years ago but are still expensive to produce compared to metal structures. Since large structures like wings cannot be removed for repairs, it's imperative that they are built right with high-quality lightning protection equipment that will perform for the life of the aircraft.

Parker static dissipating tubes: tested and proven in the air

Parker's fuel and vent line static dissipating tubes have flown over 250,000 hours in demanding applications. The components are currently installed on all HondaJet business aircraft as well as Northrop Grumman Global Hawk unmanned aerial vehicles. Available in multiple diameters, including 1/2-, 3/4-, 1.0-, 1.25-, 1.5-, 1.75-, 2.0-, 2.5-, 3.0-, 3.5-, and 4.0-inch inner diameter, the tubes are available with ferrules on each end and tubes with a flange mid span to meet most installation requirements.

With a forward-thinking design, and using patented manufacturing technologies, Parker static dissipating tubes are engineered to provide exceptional insulation resistance without reducing flow rates or requiring special adapters or modifications. Compatible with multiple tube material options, Parker's static dissipating tubes offer system application flexibility and ease of maintenance.

Current manufacturing challenges, methods, and future needs

As aircraft manufactures continue to advance their manufacturing processes to speed production of composite wings, lighting equipment protection suppliers will need to keep pace with increased market demand. **Current production methods that are hand-labor intensive will have to shift to more automated manufacturing techniques that deliver high-quality, repeatable products at lower costs.**

To deliver the results needed on composite wings, streamline productivity, and add value for customers, suppliers need to make newer manufacturing technology investments in key areas.

Advanced robotic technology will be necessary to lower the costs and achieve zero defects for lightning-protection equipment products while ensuring repeatability. With the growing use of composites, some robot manufacturers see composites as their next big growth area in aircraft manufacture. Smaller component manufacturing design teams need to explore new automation and control technology to achieve the higher production speeds that aircraft makers are already achieving.

Robotic technology will be necessary to lower costs and achieve zero defects in lightning protection equipment.

To deliver the results needed on composite wings, streamline productivity, and add value for customers, suppliers need to make newer manufacturing technology investments in key areas.

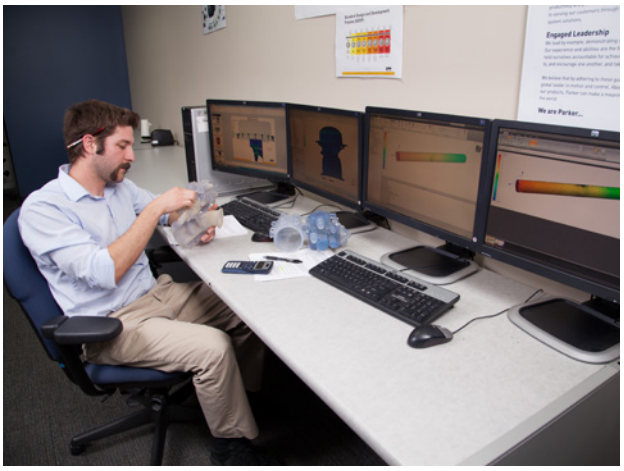
Whether metal- or composite-based, more sophisticated **additive manufacturing (AM)**, also known as 3-D printing, is proving to reduce waste, speed production, and enable designs that might not be feasible with conventional production processes[1]. AM applications are limitless and employ the use of a computer, 3-D modeling software (computer-aided design or CAD), and machine equipment to form 3-D objects by layering a material. GE and Parker recently collaborated with an AM specialist to design an aerospace fuel nozzle that combined 20 parts into a single unit weighing 25 percent less than its predecessors while achieving five times the durability[2]. GE, Parker Hannifin, and other key aerospace players have dedicated AM centers to accelerate innovation and to support a variety of aircraft clients.

Parker's dedicated corporate innovation center in Macedonia, Ohio helps to accelerate the understanding of potentially valuable and disruptive manufacturing technologies, such as additive manufacturing, throughout the corporation.

Comprehensive testing services need to go hand-in-hand with the manufacturing process, beginning at the product development stage and continuing through certification standards. The latest generation of pneumatic test rigs is a requirement for aerospace suppliers to ensure their materials, components, and systems perform consistently with fully validated simulations that test even the most extreme operating conditions. Facing increasing pressure to increase fuel efficiency, aerospace suppliers need to look at every possible improvement to lower operating costs for their aircraft customers.

Testing of lightning strike mitigation equipment.

Advanced simulation software is of the utmost importance to composite aircraft wing manufacturers and lighting protection equipment suppliers. New software algorithms can precisely calculate load paths and lightning paths, helping engineers know exactly where to distribute composite fibers based on their strength and where to install connections and inline lighting dissipation components.



Advanced simulation software and 3D-printed prototypes assist in bringing products to market quickly.

What to look for in a lightning protection equipment supplier

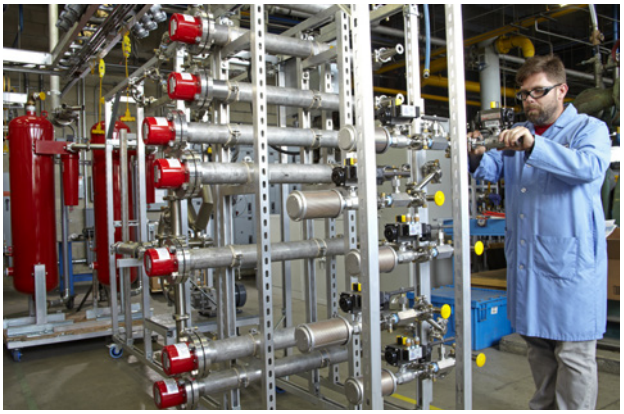
Aircraft manufacturers evaluating suppliers should be looking for a partner that will work with them collaboratively to drive innovation, lower operating costs, and deliver high-quality products that ensure safety in flight. When conducting due diligence on a business partner's history, consider the following criteria to evaluate their value:

- **Financial stability** – Is the supplier solid financially, and do they have the capacity and capital to meet prototype and production requirements?
- **Equipment effectiveness** – Do their design solutions meet program requirements and satisfy all industry-related design and manufacturing standards as well as relevant safety regulations and certifications?
- **Test and validation capabilities** – Does the supplier have the ability to thoroughly test its designs to ensure maturity at entry into service? What are their testing methods?
- **Manufacturing acumen** – Can the supplier demonstrate its ability to repeatably manufacture a durable product? Is the supplier engaged in activities to continually improve its manufacturing and automation IQ to support future program cost reduction requirements?
- **Reduced installation and purchasing costs** – In addition to delivering a successful design solution at the desired build rates, what can the supplier do to reduce the installation costs of its product? Can it make design modifications or provide kits to optimize aircraft assembly time? Does the supplier have the experience to partner with you in order to simplify the part number count and provide the equipment just in time?

Parker Aerospace, Fluid Systems Division facility in Naples, Florida.

Fuel isolation tube

- **Internal research and development** – Is the supplier looking ahead to the next generation of requirements and are they eager to implement product improvements in future designs?
- **MRO and engineering support** – Does the supplier offer robust aftermarket support of its products and use lessons learned from fielded product to implement product improvement over the life of a program? Can the supplier support your MRO needs globally if needed?
- **A track record of excellence** – The best suppliers will have a full resume with years of industry challenges they have solved and top-level customers that you can engage with to assess their level of satisfaction with that supplier. What is their pedigree and who are their customers?
- **A commitment to sustainability** – Does the supplier recognize the connection between the health of its company and economic, environmental, and social factors? Do they use resources responsibly and engage in programs that benefit local communities?



Rigorous testing capabilities ensure long product service life.

Conclusion

As composites continue to assume an increasing role in the aviation industry, the supply of high-performing lighting protection equipment will need to keep pace with aircraft design and construction to help maximize the advantages of composite materials while minimizing limitations. To ensure that suppliers emerge as successful partners, they will need to invest in new automated manufacturing processes, advanced robotics technology, additive manufacturing, testing capabilities, damage detection, and repair methods to compete in an arena where aluminum aircraft construction may someday become obsolete. For now, understanding exactly how metal and composite structures work together, reducing weight and connections, and producing reliable and repeatable components and structures are providing a healthy balance of economics and safety.

About Parker Aerospace

Headquartered in Irvine, California, Parker Aerospace is an operating group of Parker Hannifin Corporation and a global manufacturer of flight control actuation, hydraulic, fuel, inerting, fluid conveyance, pneumatic and lubrication systems and components used on virtually every commercial and military aerospace platform in production today.

Dedicated to the safety of flight, Parker offers a comprehensive array of lightning protection equipment that's fully tested to meet the most stringent commercial and military regulations for lightning, fire, and flammability. Parker's lighting lab testing engineers are active members of the SAE A-2 Lighting Safety Committee.

For more information on Parker's Lightning Safe® products

- Please visit our lightning protection blog **here**
- **Download** white paper number 1 in our two-part series

Parker Aerospace On-Site Testing Capabilities for Lightning and Fire

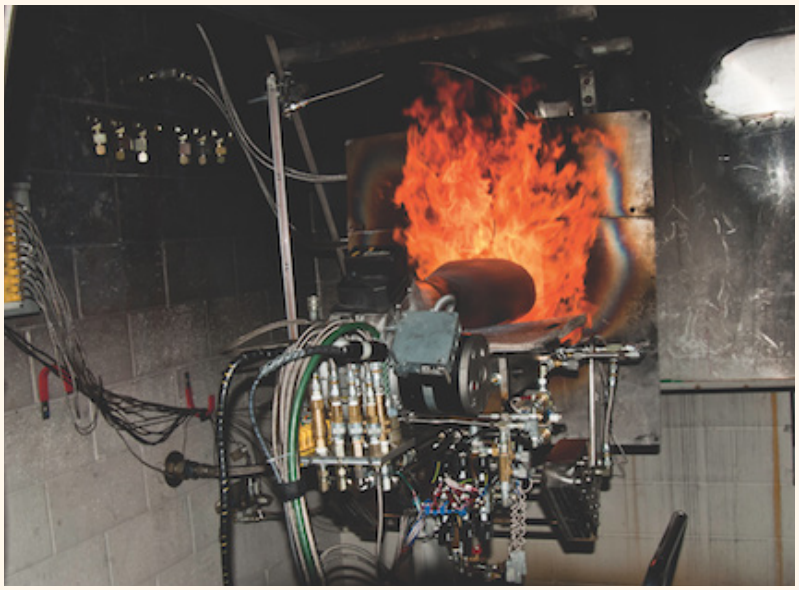
The Fluid Systems Division (FSD) of Parker Aerospace has an in-house, direct-effects lightning test laboratory offering unique and specialized capabilities that meet broad requirements. This advanced testing ensures Parker's Lightning Safe® products are certified to the most stringent commercial and military regulations for lightning, fire, and flammability.

Lightning testing capabilities

- Meet broad requirements of:
  - MIL-STD-1757A
  - FAA-AC-20-53A, RTCA
  - DO-160D, Sct. 23 ARP 5412
- Up to 200 kiloamperes oscillatory current waveform
- Up to 3,000 amperes unipolar mixture ignition detection
- Over 2,500 mf at 5,000 volts
- Over 60 mf at 45,000 volts

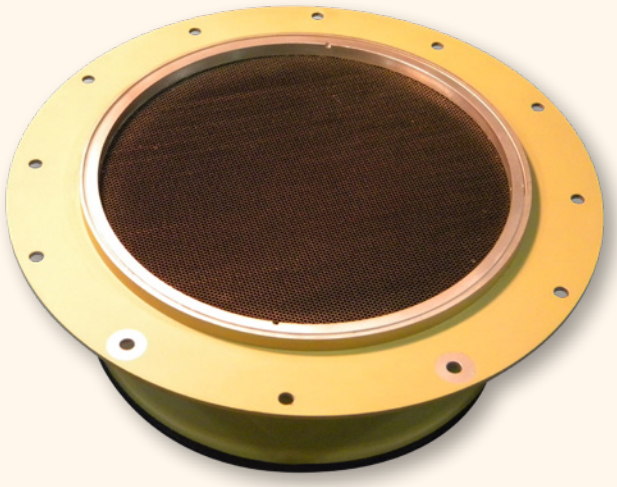
FAA fire testing capabilities

- Fire-resistant up to 2,000 degrees Fahrenheit for 5 minutes
- Fire-proof up to 2,000 degrees Fahrenheit for 15 minutes
- Testing in accordance with AS1055B, AS4273, AC20-135, AIR 1377
- Testing of oil tanks, filler caps and necks, hoses, sight gauges, and many other components



Flame arrestor testing capabilities

- First to address SFAR88 requirements with flame arrestor technology
- Testing per AS1055B, AS4273, AC20-135, AIR 1377, AC 25-975
- Flame arrestor/flame holding
  - Vaporized hexane or jet fuel
  - Heated air/fuel mixtures up to 400 degrees Fahrenheit (201 degrees Celsius)
  - Air and mixture flows over 10 scfm
  - Air flows up to 200 scfm
  - Data acquisition software that monitors and collects data requirements



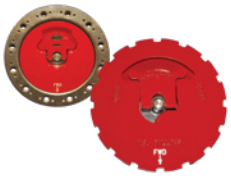
Flame arrestor

Parker Aerospace offers a comprehensive line of lightning and flame protection equipment

Static dissipating tubes – Installed in-line with the fuel lines and fuel vents of an aircraft, these tubes are designed to slowly dispel the static charge from a lightning strike. Complete isolation is not the objective as this would lead to lighting strike electrical energy arcing across large gaps with the potential of fuel ignition. The high resistivity range of these tubes protects the fuel lines and the rest of the fuel system from possible combustion.

Flame arrestors – Typically installed in the fuel vent line(s) of an aircraft fuel system, flame arrestors prevent a flame originating at the vent outlet from propagating into the fuel tank and causing ignition of fuel vapors in the fuel tank. Lightning strikes can cause ignition of the flowing fuel/air mixture, so flame arrestors are a critical deterrent needed on wings.

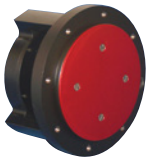
Lightning-safe fuel caps and mating adapters – With the increased use of composite materials in aircraft design, fuel caps and mating adapters ensure safe lightning protection and provide passage of jet fuel fluid through a fuel tank or other areas.



Drain valves – Lightning-safe drain valves are specially designed for fuels used on composite aircraft. Constructed of stainless steel, titanium, aluminum, or plastic, they can be manually or electronically actuated with self-closing, locked-open, or locked-close poppets depending on the manufacturer. These can withstand direct strike from lightning and dissipate that energy into the conductive wiring path.

Magnetic fuel level indicators – Magnetic fuel level indicators provide a zero-leakage auxiliary method of gauging fuel tank quantity from outside the aircraft. A sealed tube assembly is mounted to the lower wing skin. An inner indicating stick with magnets, calibrated for individual applications, is positioned so an annular float with magnets will move up and down the outer tube with changing fluid levels. This lighting-safe equipment bypasses any need for electrical wiring or cables that can deliver lighting currents to a fuel source.

Pressure relief valves – Lighting-safe pressure relief valves are designed to prevent excessive pressure or vacuum buildup in the fuel tank's sealed environment with highly resistive properties that resist static charge.



Locking fuel cap – Offers a locking mechanism to avoid tampering while providing lightning protection for the aircraft wing.

Dielectric isolator – Dispels static charge from a lightning strike.

Dual flapper check valve – Designed to prevent back pressure / negative pressure.

High pressure isolator – Also known as highly resistive union, provides lightning protection for the entire life of an aircraft.

Pressure fuel servicing assembly – Allows for high-speed pressure fueling of aircraft.

Vent valve suction assembly – Prevents excessive pressure buildup in fuel tanks.

References

1. Bullis, Kevin. “Advanced Manufacturing Is Reshaping Aircraft Design.” MIT Technology Review, MIT Technology Review, 6 Feb. 2015, www.technologyreview.com/s/534726/additive-manufacturing-is-reshaping-aviation/.

2. Kellner, Tomas. “How 3D Printing Is Changing Aerospace Manufacturing - GE Reports.” Imagination at Work, GE, 14 Sept. 2017, www.ge.com/reports/mind-meld-ge-3d-printing-visionary-joined-forces/.

Systems strength. Component solutions.

M&K 11/19

Parker Hannifin Corporation
Parker Aerospace
6035 Parkland Boulevard
Cleveland, Ohio 44124-4141
phone +1 216 896 3000
www.parker.com