



## Fluid Atomization Innovation

Improving your performance, delivering greater value

**aerospace**  
climate control  
electromechanical  
filtration  
fluid & gas handling  
hydraulics  
pneumatics  
process control  
sealing & shielding



ENGINEERING YOUR SUCCESS.



Where can you find Parker fluid atomization innovation? In the heart of the most powerful gas turbine engines in the world. Cooling electronics and aircraft. And powering industrial and commercial applications on both land and sea.

### 1950s

- 1949: GE J47
- 1959: GE J79

### 1960s

- 1962: T55 Lycoming
- 1965: PWA GG4
- 1966: Pratt & Whitney J58
- 1968: GE CF6-6

### 1970s

- 1970: Allied Signal TFE731
- 1970: GE LM2500
- 1970: GE LM5000/6000
- 1973: GE F101
- 1975: GE F110
- 1977: CFM CFM56
- 1977: GE F404

### 1980s

- 1982: Rolls-Royce RB211-524
- 1982: Rolls-Royce RB211-535
- 1985: GE LM1600
- 1989: Alstom GT11N2
- 1989: Pratt & Whitney PW229

### 1990s

- 1992: GE CT7
- 1992: GE GE90
- 1992: Rolls-Royce Tay
- 1992: Rolls-Royce Trent 700/800
- 1993: Alstom GT13E2
- 1993: GE LM6000 DLE
- 1993: Pratt & Whitney F119-PW-100
- 1995: GE LM2500 DLE
- 1996: GE CF34
- 1996: Siemens 501F
- 1996: First commercial application of Macrospray® technology
- 1997: Alstom GT24
- 1997: Alstom GT26

Key:

- Pressure atomizer
- Airblast nozzle
- Aero derivative
- Augmentor
- Power generation



Macrolamination technology enables atomization devices that better disperse fluids.

## Macrolamination: Channeling complex fluid passages

Developed by Parker, macrolamination technology utilizes digital tooling for precise placement of critical geometries essential for targeted fluid atomization and thermal management performance.

These geometries are integrated into layers that provide smooth, efficient flow passages, and also allow complex or multiple flow circuits to be produced more cost effectively. The layers are then bonded together, forming a monolithic structure with bonded joints as strong as the parent material.



Macrospray® nozzles generate droplets less than 15µ (SMD) at 600 psi pressure with useful sprays observed at pressures as low as 5 psi.

### Proven leadership

Over five decades of experience have made the Parker Aerospace Gas Turbine Fuel Systems Division the acknowledged leader in fluid metering, delivery, and atomization devices, liquid cooling systems, and aircraft and engine thermal management systems. Our legacy, current, and future programs give us the edge, and the expertise, to design and manufacture

systems, subsystems, and components that stay on wing and in service longer. Our reliable systems are derived from our unique, proprietary design and manufacturing technologies that result in improved nozzle and combustor performance. And we lead the way with advanced emissions (NO<sub>x</sub>, CO) abatement technologies.

#### 1990s (continued)

- 1997: Ansaldo 64.3A
- 1997: Ansaldo 94.3A
- 1997: BMW Rolls-Royce BR710/715/725
- 1997: GE Frame 6FA/9EC
- 1998: Alstom GT8C2
- 1998: GE F414
- 1998: Siemens 501G
- 1998: First comprehensive fuel delivery system
- 1998: First cooling system for higher-powered electronics

#### 2000s

- 2000: Rolls-Royce Trent 2000
- 2002: Rolls-Royce Trent 1000
- 2003: BMW Rolls-Royce Trent 500
- 2003: Rolls-Royce WR21
- 2004: GE LMS100
- 2004: Rolls-Royce MT-30
- 2005: GE/Pratt & Whitney GP7200
- 2006: Advanced thermal management technology created
- 2007: First commercial application of advanced thermal management technology – Boeing 787
- 2009: GE GEnx
- 2010: SprayCool® joins Parker

# Nozzles with lower emissions



Trent 1000 fuel manifold

Trent 800 nozzle

GE90 dual nozzle

### Unrivaled leadership

As part of the Parker Aerospace Group of Parker Hannifin Corporation, a world leader in aerospace and other advanced motion and control technologies, we earned our reputation by creating fuel injection systems and components for commercial engines from such respected manufacturers as General Electric, Pratt & Whitney, and Rolls-Royce. Right now, our advanced fluid metering, delivery, and atomization devices and systems can be found on the engines powering the largest commercial transports flying today. In fact, Parker Aerospace has more fuel nozzles in service on today's engines than any other manufacturer. Our nozzles offer the proven reliability of billions of logged service hours, and are engineered to withstand the higher thrust and temperatures of today's newer and larger engines while still delivering the lowest emissions on record.

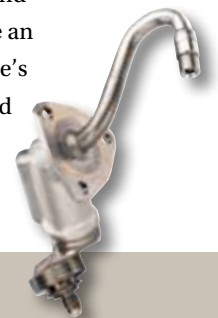


GENx nozzle

### Macro Spray® technology: Critical path for low emissions

Our proprietary macrolamination technology utilizes digital tooling for the precise placement of critical geometries essential for smooth, efficient flow passages.

This innovation is found in the fuel spray nozzles on General Electric's GENx, the high-efficiency, ultra-quiet, ultra-performance engine selected to power the Boeing Dreamliner and 747-8. Parker nozzles are an integral part of the engine's low-smoke, low-NO<sub>x</sub>, and low-CO performance.



### Completely customer focused

Working with such leading engine manufacturers as General Electric, Pratt & Whitney, and Rolls-Royce, we have developed partnerships that allow us to respond more quickly to evolving engine requirements. Our teams are highly customer focused and adapt readily to the needs at hand, working on site with customer staff to create customized solutions that meet program needs.



# Nozzles with proven reliability

## Billions of logged service hours

Parker has more than five decades of experience creating fuel injection systems and components for both regional and business jets on engines from various power plant manufacturers, particularly Honeywell and Rolls-Royce.

Programs include the Gulfstream 650, the Embraer 190, the Dassault Falcon 900 and Falcon EX, the Raytheon Hawker 900, and the COMAC ARJ21.

For all these aircraft, our fuel nozzles offer the proven reliability of billions of logged service hours, with a half billion more on-wing hours added every year. It's the kind of performance that translates into optimum combustion, greater fuel-burning efficiency, lower emissions, and reduced cost of ownership.



BR725 nozzle



CF34-10 nozzle



TFE731 fuel manifold

## APU nozzles

Parker fuel nozzles also play an important role in the reliable and efficient operation of auxiliary power units (APUs). Parker's APU nozzles provide better atomization performance, greater combustion efficiency, and higher-altitude reflight capability, while maintaining the same proven reliability as the main engine nozzles.



# Nozzles with higher performance



F414 nozzles, spraybars, and manifold

## Fuel burn on demand

When military pilots feel the need for speed, it's Parker fuel injection systems and components that respond. Over five decades of development have made us the acknowledged experts in advanced fluid metering, delivery, and atomization, giving us the experience needed to design and manufacture advanced fuel injection systems that ensure optimum combustion performance.

Working in concert with all the major military engine manufacturers, including General Electric and Pratt & Whitney, we have been able to develop nozzles that can meet the higher thrust and temperature demands of today's advanced engines while providing lower emissions. Case in point? The F414-GE-400 engine. Equipped with Parker nozzles, spraybars, and manifold, the F414 delivers 35 percent more thrust than its F404 predecessor — thrust made possible in part by Parker.



## A powerful track record of development

From GE's J79 engine, which set speed and altitude records (1400 mph / 91,249 feet) in a F-104 Starfighter, to Pratt & Whitney's F119 engine, which has logged over 100,000 flight hours powering the Lockheed Martin F-22 Raptor, Parker has played an integral role in furthering the development of fuel injection systems for advanced military engines.

## Reduced costs, increased support

Our customer support arm is especially sensitive to the needs of our military customers. That's why we offer customizable service options that share the risk, as well as the reward, of lifetime support.

From cost-per-hour programs to dispatchability requirements and fixed maintenance pricing, our military customers can choose options that deliver new levels of service and accountability.



F414 nozzle



PW119 nozzle



PW229 nozzle

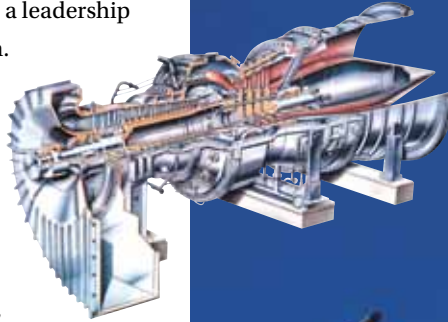


J69 nozzle

# Better combustion for cleaner-burning engines

## Proven leadership

Nozzle reliability and higher sustained performance have earned us a leadership position in power generation. Our experience in aerospace has directly translated into innovative nozzle designs for power generation that offer improved fuel flow, atomization, and placement, as well as better combustion for cleaner-burning engines. Because the demand for low-emission engines is increasingly critical, emission reduction is a priority for us — as well as a clear competitive advantage for you. In addition, we offer dedicated power generation manufacturing facilities as well as lifetime technical, overhaul, and customer support.



## Meaningful differentiation

Our expertise in gaseous, liquid, or combined fuel applications — with or without water or steam injection — helps us create meaningful differentiation for our customers. Drawing upon a technology database of proven products and processes, we are able to offer flexible and targeted solutions that result in shorter development time and reduced cost.



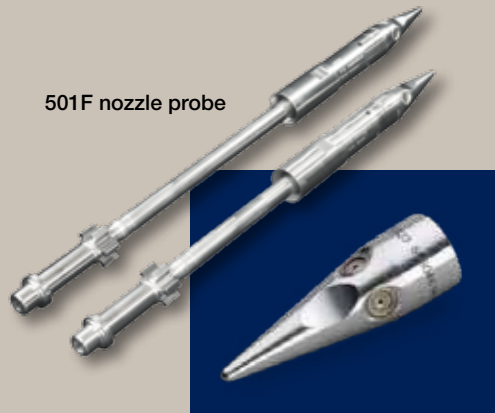
Nuovo Pignone PGT 10



GT13E2 burner

## MacroSpray® technology: Premier performance on your program and bottom line

Our power generation fuel nozzles provide lower installed and lifecycle costs due in large part to our proprietary MacroSpray® technology. This technology simplifies nozzle design, resulting in the enhanced performance that boosts reliability.



501F nozzle probe



LMS100 gas nozzle



LM6000 gas/liquid nozzle



GE frame nozzle



LM6000 gas nozzle

# Advanced engineering, integrated processes, continuous improvement

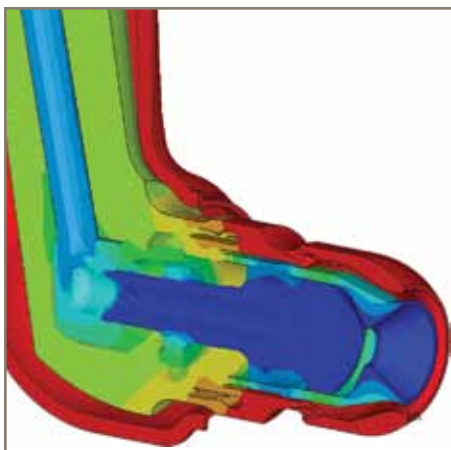
## Optimized design through advanced engineering

Parker's proprietary design tools and procedures are used to optimize design performance and achieve advanced fluid atomization. State-of-the-art computing resources and analysis software — including 3D design, finite

element analysis, and computational fluid dynamics — are applied to improve product performance. Design of experiments (DOE), design for six sigma, spray, and combustion

**First look ahead** – Computational fluid dynamics predict product performance.

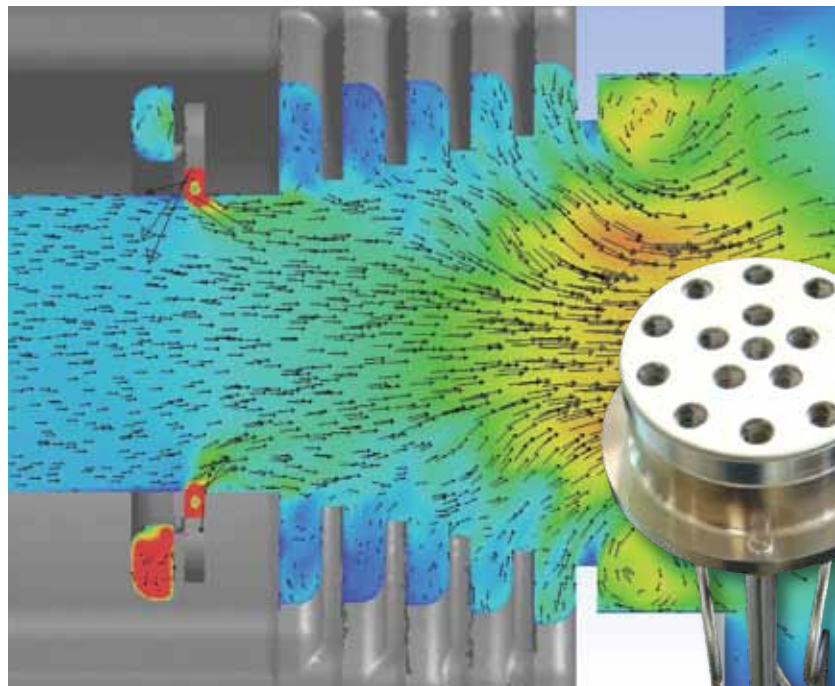
experiments are then used to optimize and validate product and process performance. Stringent in-process tests and adherence to ISO and AS standards keep product integrity and customer satisfaction high.



**Developing durability** – Finite element analysis predicts product life.



**Design validation** – Spray (left) and combustion experiments confirm design intent.



**High-performance partnerships** – This Department of Energy H<sub>2</sub>/syngas injection system produces less than 5 ppm NO<sub>x</sub> emissions at relevant gas turbine conditions.



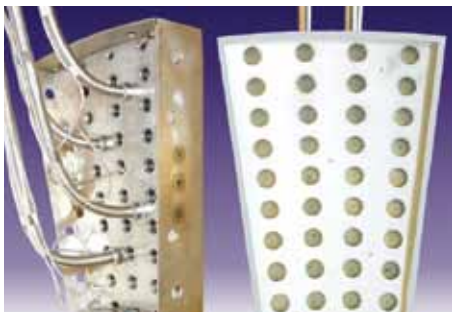
## Continuous improvement

Every Parker Aerospace employee actively pursues the goal of continuous improvement. In order to better understand issues at every level, we function as a business partner as well as a technical partner. Structured into business teams, we work jointly with our customers to achieve faster product development, superior quality, and consistent, on-time delivery that can lead to meaningful competitive advantage.

Not only that: our dedication to lean enterprise principles is unwavering. We are committed to lean development, lean procurement, and lean office principles, measuring our performance through well-established metrics that are openly displayed and regularly updated.

## High-level design solutions

Parker's fuel atomization designs power today's most advanced engines. By leveraging our significant in-house resources, and forming partnerships with other leading research organizations, we are driving the future of fuel injection system design, continually raising the bar for efficiency and emissions.

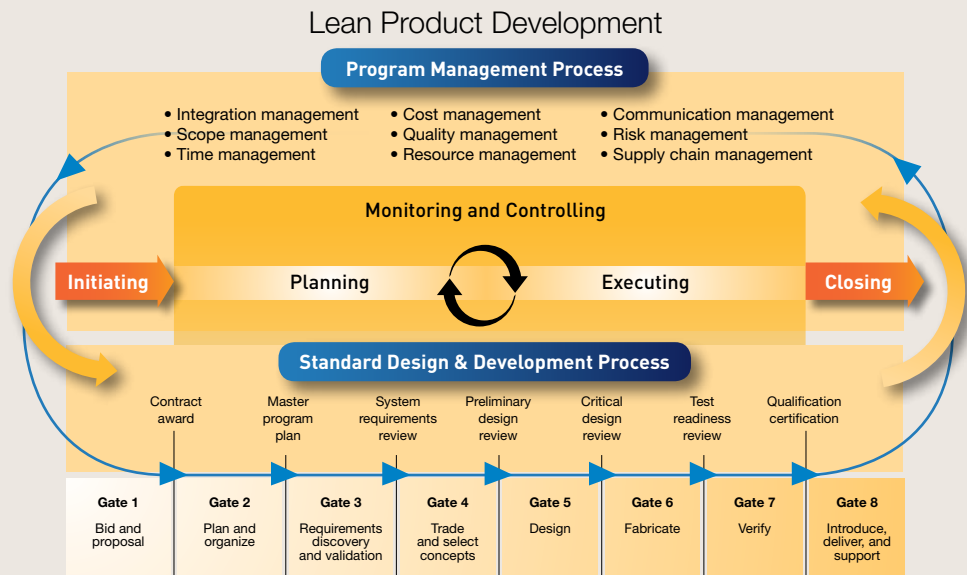


Setting new standards – NO<sub>x</sub> emissions from this NASA-funded UEET injector are 17 percent of the 1996 ICAO standard.

## Standard design and development process (SDDP)

SDDP is a proprietary Parker Aerospace development process conducted in concert with a corporate-wide program management initiative to improve product performance, shorten development time, and reduce cost.

SDDP takes program management to new heights. Detailing program management steps from bid and proposal to entry into service, it identifies the activities, inputs and dependencies, completion criteria, and best practices needed to successfully complete any one specific program.



With a management process that is segmented into eight stages, SDDP ensures that activities are performed and deliverables are reviewed and approved at each stage of product development. SDDP's standard methodology also encourages completeness while minimizing waste as part of our commitment to lean product development.

# Higher heat removal with greater design flexibility

The command, control, communications, computing, intelligence, surveillance, and reconnaissance (C4ISR) electronic warfare systems required to satisfy the real-time situational awareness needs of today's warfighters are driving ever-increasing power densities at the board, system, and platform levels.

Parker Aerospace advanced thermal management technologies, including next-generation SprayCool® multi-platform enclosures (MPE) and liquid flow-through components, offer revolutionary heat collection and heat rejection systems for unparalleled design flexibility.

## SprayCool® direct spray cooling

Using a non-conductive, non-corrosive liquid applied directly to electronics, SprayCool® technology removes heat via a

**SPRAYCOOL®** forced convection and phase change from liquid to vapor. The closed-loop system isolates electronics from harsh environments. This enables the flexible selection of all electronics (commercial, industrial, and ruggedized), and offers efficient and low-system-cost performance, within a ruggedized environment.

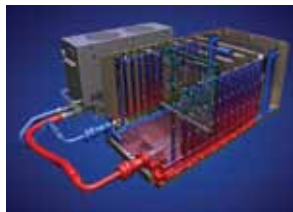
The Global Hawk and Sky Warrior unmanned aerial vehicles, Black Hawk helicopter, and ground mobile platforms like the Expeditionary Fighting Vehicle (EFV) and Medium Extended Air Defense System (MEADS) are using SprayCool® enclosures to enable both current and next-generation electronics.



UAV aircraft like Northrop Grumman's RQ-4 Global Hawk rely on SprayCool® thermal management technology for electronics cooling in unpressurized space.

## Liquid flow-through cooling

Our macrolamination technology enables new levels of flexibility and thermal efficiency for liquid flow-through chassis, flow-through modules, and coldplates. Focused cooling locates coolant only where it is needed, considerably reducing size, weight, and power. Liquid flow-through systems enable the use of conduction-cooled electronics in extended-temperature environments, creating more computing throughput or higher-powered electronics in smaller packages for military, aerospace, industrial, and commercial applications. These systems provide the flexibility of local or remote heat rejection, operating with many thermal fluids common to aircraft and ground vehicles.



SprayCool® MPEs are scalable, flexible, and rugged, with a cooling capacity up to 2000W when paired with a heat exchanger.

## Other specialized applications for MacroSpray® nozzles

From chemical processing and fuel cells to dust control, livestock cooling, and pharmaceutical



manufacturing, our MacroSpray® nozzles offer the benefits of precise fluid placement, smaller drop size, uniformity

of spray patterns, and cleaner, faster startups and shutdowns without nozzle drool.

MacroSpray single-point nozzles offer better performance at lower pressures. Smaller packages make them excellent for hard-to-reach applications.



MacroSpray spider nozzles provide much greater coverage area. This translates into quicker, less expensive installation and lighter system weight.

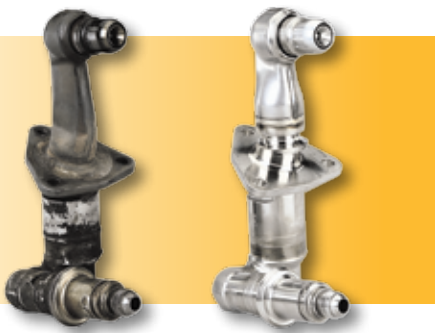


# Wherever you need us

## Local in more locales

Parker's customer-focused philosophy extends well beyond the manufacturing floor. Our worldwide MRO facilities provide support through the entire product lifecycle, supplying even your remotest installation quickly.

With facilities in North America, Europe, and Asia, we can provide the guaranteed turnaround time you need to support demanding maintenance schedules.



Parker can repair fuel nozzles, or overhaul them to new nozzle specifications.

## Customized support agreements

When it comes to MRO, we continue to be at the forefront of customer support by improving the way we do business through innovation. Our forward thinking allows us to take a proactive approach to MRO systems integration, customized programs, flight hour agreements, and inventory logistics support. On-site technical service, 24-hour global support, cost-per-hour programs — the choice is yours. But the affordability and the reliability? That's all ours.

## Training

To help keep customers going long and strong, we're providing operators with frontline technical support for their new or existing aircraft and engines. As users receive new equipment, Parker people are by their side, demonstrating how to support, service, and troubleshoot Parker systems and components. This new approach to system-level support and training is in addition to traditional MRO services, and includes on-site technical support sessions, regional training symposiums with multiple operators, and web-based training courses.



## Online support

PHconnect, Parker's secure and personalized e-business website, offers around-the-clock customized support, including:

- Spares pricing and lead time
- Open order status
- Inventory availability
- Requests for quotes
- Order placement
- Credit card payment
- Shipment status
- Invoice viewing
- Open invoice and aging information
- Printing duplicate invoices

PHconnect also serves as a vehicle for training schedules and registration, as well as an idea forum for operators.

To find out more about our ongoing support, contact our customer support operation at **(623) 872-1800**.

# Parker Gas Turbine Fuel Systems Locations and Operations

## **Division Headquarters:**

### **Mentor, Ohio**

*Aerospace combustion products,  
thermal management systems,  
and Macrospray® industrial fluid  
atomization products*

8940 Tyler Boulevard  
Mentor, OH 44060 U.S.A.  
phone 440 266 2300  
fax 440 266 2399

### **Clyde, New York**

*Marine, commercial, military, and  
industrial combustion products*

124 Columbia Street  
Clyde, NY 14433 U.S.A.  
phone 315 923 2341  
fax 315 923 9306

### **Glendale, Arizona**

*Maintenance, repair, overhaul,  
and fleet management*

7777 N. Glen Harbor Boulevard  
Glendale, AZ 85307 U.S.A.  
phone 623 872 1800  
fax 623 872 8595

### **Liberty Lake, Washington**

*Thermal management systems,  
including SprayCool® products*

2218 North Molter Road  
Liberty Lake, WA 99019 U.S.A.  
phone 509 232 2600  
fax 509 444 1082

### **Moncks Corner, South Carolina**

*Larger-frame power generation  
combustion products*

1460 Garrot Avenue  
Moncks Corner, SC 29461 U.S.A.  
phone 843 719 8100  
fax 843 719 8168

### **Selangor, Malaysia**

*Maintenance, repair, and overhaul*

Parker Hannifin (Malaysia) Sdn. Bhd.  
Parker Aerospace  
Gas Turbine Fuel Systems  
Lot 9, Jalan U1/26  
Hicom-Glenmarie Industrial Park  
40000 Shah Alam  
Selangor, Malaysia  
phone 011 603 78061528  
fax 011 603 78034526

### **Wiesbaden, Germany**

*Maintenance, repair, and overhaul*

Lorenz-Schott-Strasse 9  
55252 Mainz-Kastel, Germany  
phone 49 6134 204227  
fax 49 6134 204188