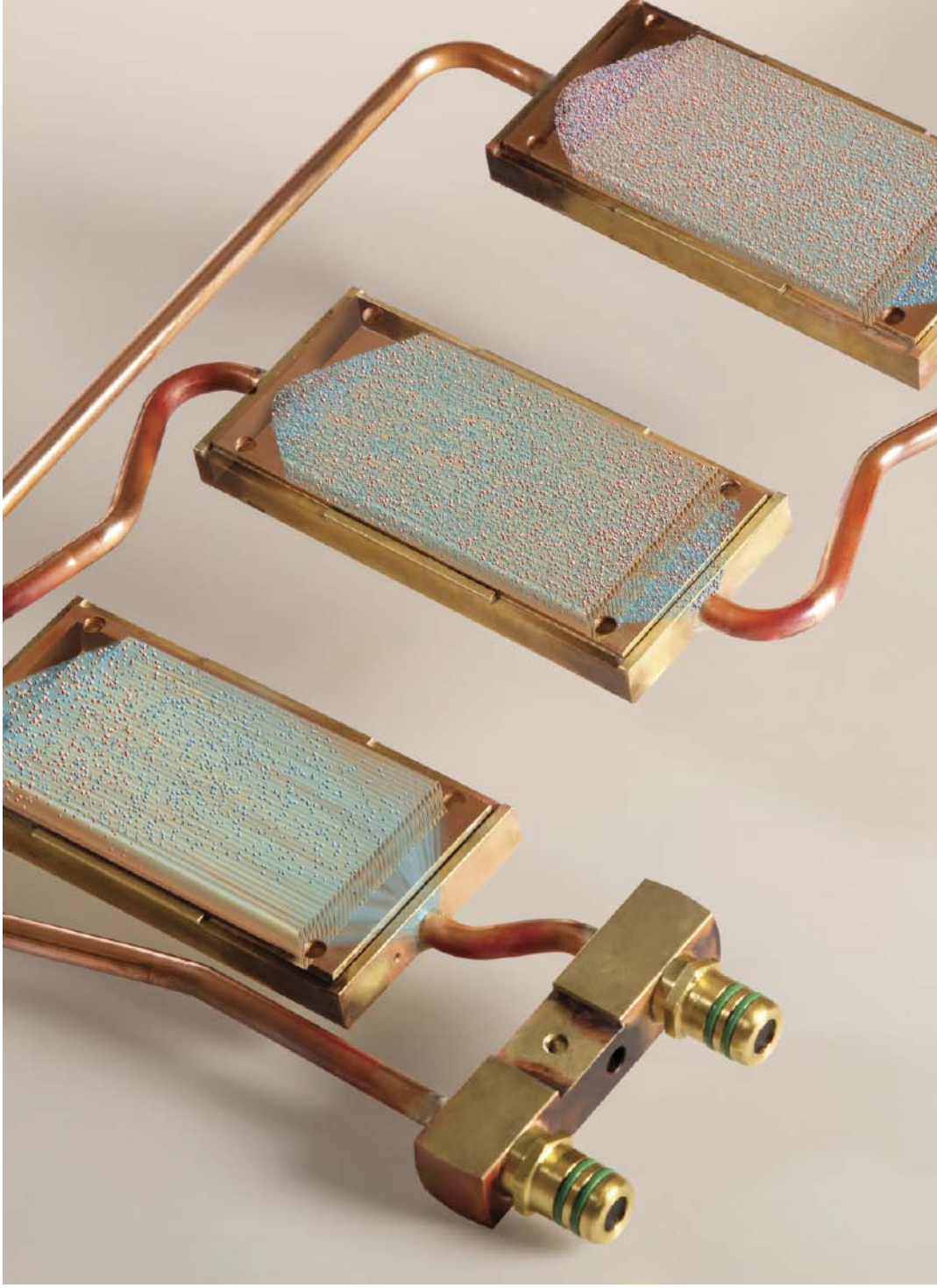
aerospace
climate control
electromechanical
filtration
fluid & gas handling
hydraulics
pneumatics
process control
sealing & shielding



Two-Phase Evaporative Precision Cooling Systems

For heat loads from 3 to 300kW

Parker

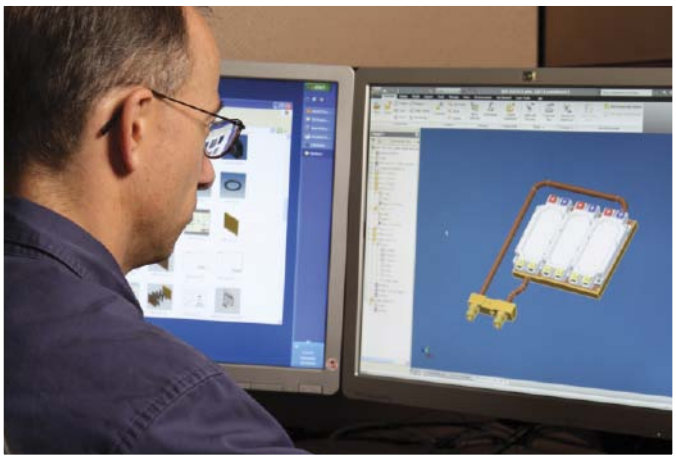
ENGINEERING YOUR SUCCESS.

Using non-conductive refrigerant fluid, our patented

Next-generation, two-phase evaporative precision cooling systems enable up to twice the power density at a lower system cost

Parker's two-phase evaporative liquid cooling system is based on our own patented technology, and uses non-corrosive, non-conductive fluid which vaporizes and cools hot surfaces on contact. Ideal for high power electronics systems where heat loads have moved beyond what traditional air and water cooling systems can effectively manage.

By combining a non-conductive dielectric refrigerant with the science of heat dissipation through vaporization, our evaporative cooling technology increases power densities for high power electronics by more that 2x.



Our evaporative precision cooling system offers a safer and more efficient method of heat transfer. Although the systems are leak tight, should an accidental leak occur, the non-conductive fluid is inherently safe even when in direct contact with sensitive electronics.

Integrating the high heat removal of two-phase technology with the reliability of low-flow liquid pumping, our system is highly modular (hot swappable) and scalable. With such high-efficiency, it simplifies the plumbing and reduces the overall weight, giving it an excellent thermal performance/cost ratio. And, due to the inherent non-corrosive properties of the fluid, no regular end user maintenance is required.

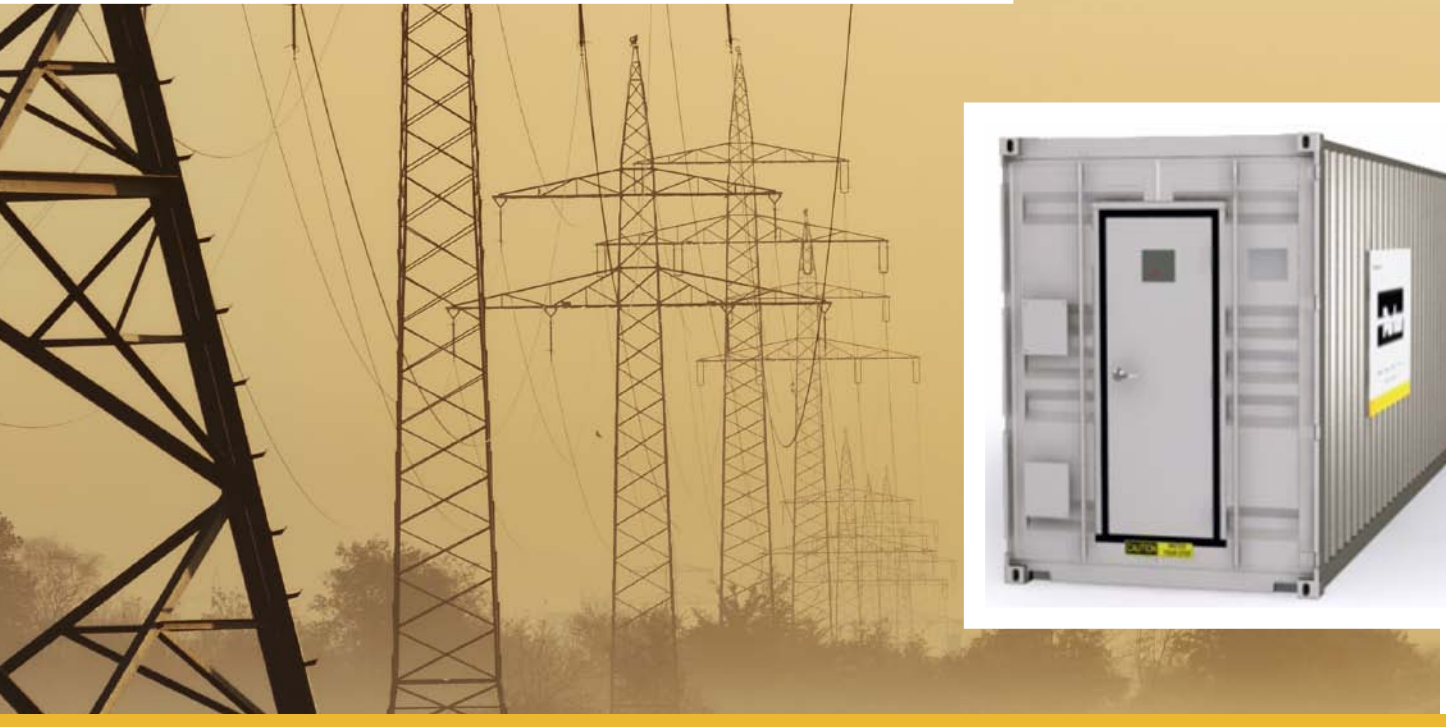
2-PHASE EVAPORATIVE COOLING SYSTEM ADVANTAGES

- Increased power density
- Reduced weight
- Smaller enclosures
- 2 to 4 times better heat transfer
- Lower flow rates – 80% less than that of EG water systems
- Increased system reliability and MTBF
- Safer – no risk of electrical shorting
- Modular; scalable; hot swappable
- No altitude or hot climate de-rating
- Isothermal, increasing silicon life and simplifying plumbing
- Smaller pumps with 50,000 L10 life
- Opportunity for reduced wiring, switchgear, magnetics
- Ability to free cool – reduced HVAC system heat load
- 85% reduced energy consumption
- Shorter commissioning time
- Maintenance-free; no set-up, biocides, filters, tear downs
- Less thermal cycling for increased electronics life

cooling technology increases the throughput of high power electronics by up to 40%.

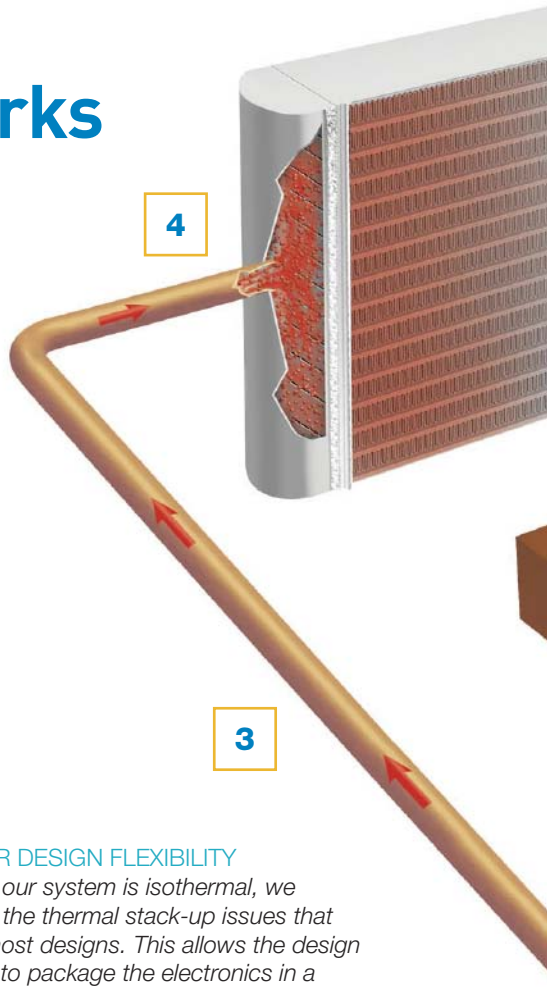
CONSIDER 2-PHASE EVAPORATIVE COOLING FOR APPLICATIONS THAT:

- Have critical packaging constraints
- Have a propensity for high cyclical loads
- Call for more power output from a given device package (e.g., increased switching frequency or difficulty in paralleling devices)
- Feature multiple loads connected in series / parallel in the cooling loop
- Need modular and easy field service (quick dry break connectors)
- Involve high-voltage and use de-ionized water
- Want to eliminate the chiller



How evaporative cooling works

1. The fluid flows through hard tubing or hose to a low-flow pump.
2. Pump moves saturated fluid across a cold plate directly underneath the heat source. With the latent heat transfer, the fluid immediately starts to vaporize.
3. Heat is carried away by the vapor.
4. Vapor moves to an air- or water-cooled condenser where it re-condenses into fluid and the heat is dissipated.
5. Excess fluid is stored in the accumulator ready to be pumped back into the system.



GREATER DESIGN FLEXIBILITY

Because our system is isothermal, we eliminate the thermal stack-up issues that plague most designs. This allows the design engineer to package the electronics in a way that makes the most sense for the application rather than make compromises because of the cooling system.

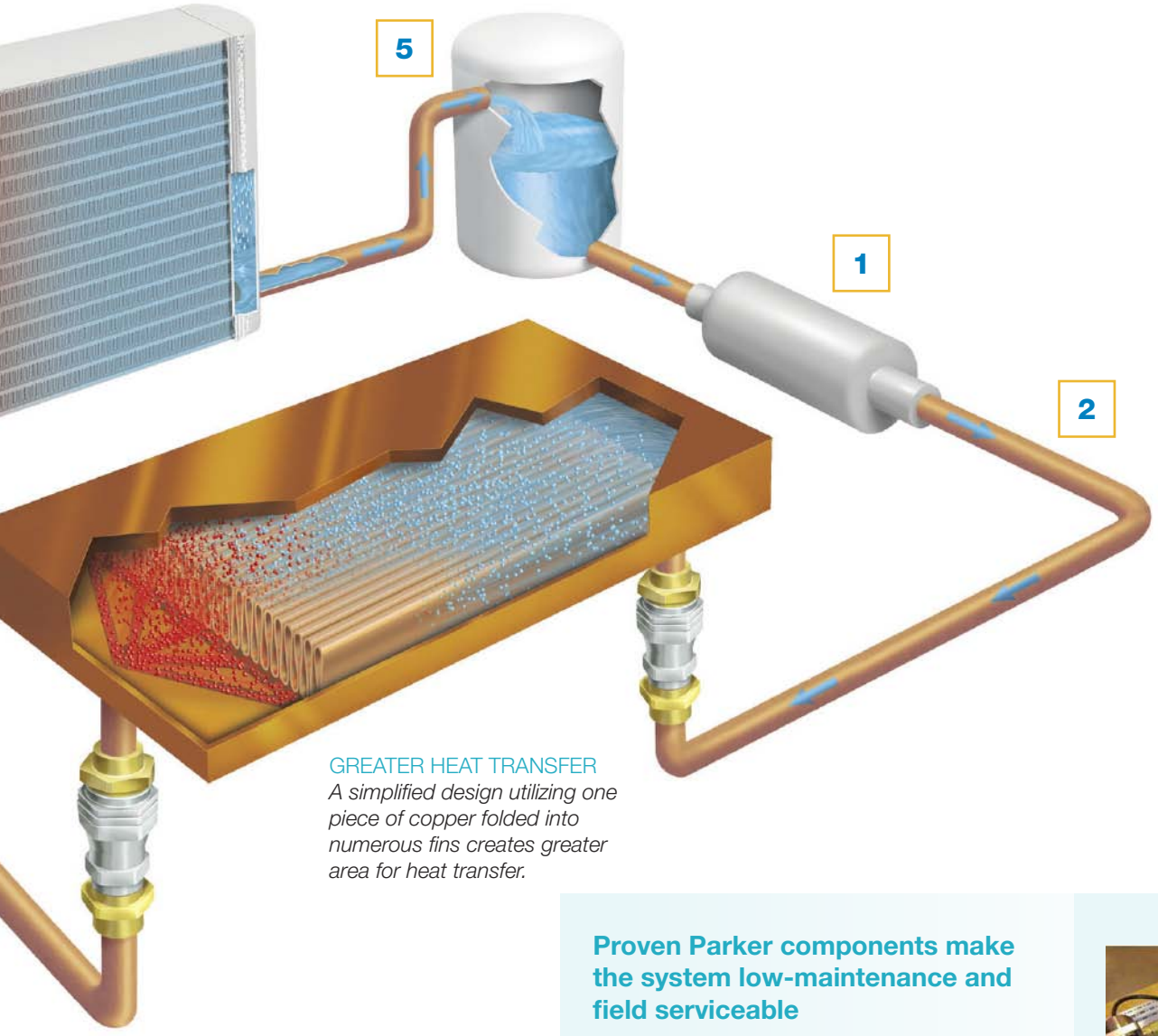
TAKING LIQUID COOLING TO THE NEXT LEVEL

This efficient cooling process continuously cycles the refrigerant within a sealed, closed-loop system to cool a wide range of systems including power electronics, motors, transformers, and batteries. The system uses a small pump to deliver just enough coolant to the evaporator - usually a series of one or more cold plates optimized to acquire the heat from the device(s). In so doing, the two-phase coolant begins to vaporize maintaining a cool uniform temperature on the surface of the device. The vaporized coolant is then pumped to a heat exchanger where it rejects the heat to the ambient and condenses back into a liquid, completing the cycle.

Dielectric Fluid – R134a

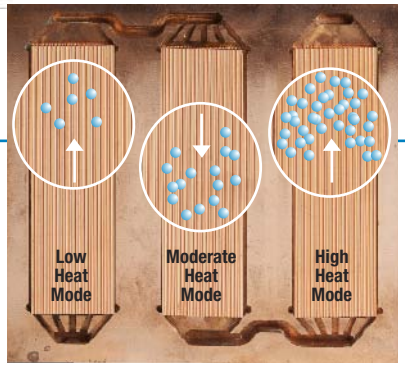
A commonly used refrigerant, R134a is dielectric, flashes to gas at ambient temperatures, does not react with metals, and is intrinsically harmless. Newer fluids are under development that have similar properties but better global warming ratings. Such fluids will be drop-in replacements.

Download technical articles and white papers at
www.parkerprecisioncooling.com



GREATER HEAT TRANSFER

A simplified design utilizing one piece of copper folded into numerous fins creates greater area for heat transfer.



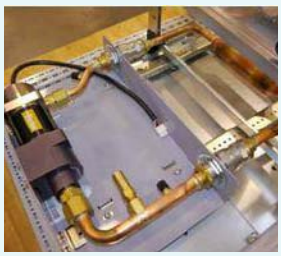
Self-optimizing and Isothermal

Utilizing latent heat transfer makes the system self-optimizing: As heat loads increase, more fluid vaporizes, taking away more heat. In addition, stack-up problems are eliminated because the temperature of every cold plate remains the same regardless of location. Consequently, vaporization temperature is constant while the amount of vaporization is variable.

Proven Parker components make the system low-maintenance and field serviceable

Dry Break Connectors

Unique to our cooling system are two dry break connectors. These allow a quick disconnect so critical system components can be rapidly isolated and serviced in the field efficiently. Dry break connectors do more than minimize maintenance downtime, though – they also make installation faster and easier.



Low-Flow-Rate Pump

Derived from Parker pumps developed for aerospace and automotive applications, the hermetically sealed pump uses positive displacement to create flow and suction to move the fluid. The pump moves the fluid through the loop at a pressure just above the level where the fluid at ambient temperature would flash to gas. A brushless DC motor provides a 50,000-hour L10 continuous-duty life.

How 2-Phase Evaporative Precision Cooling Compares

A series of tests in which we drove an IGBT module until the junction temperature reached 120ºC. We then utilized different cooling methods and measured the resulting heat loss.

Technologies	RESULTS: Module Loss (W) for 120ºC junction **Steady State**	Module Loss (W) for 120ºC junction **220% Overload**	Heat Sink/Cold Plate Resistance ºC/W
 **Convection Air:** *40ºC ambient, 150CFM*	600	405	0.094
 **Pressed Tube Water Cold Plate:** *3 cold plates; 6 gpm; 40ºC ambient; 50ºC fluid temperature*	736	437	0.051
 **Extended Surface Water Cold Plate:** *3 cold plates; 6 gpm; 40ºC ambient; 50ºC fluid temperature*	1070	500	0.035
 **Parker Two-Phase Extended Surface With R134a:** *3 cold plates; 1.2 gpm; 40ºC ambient; 50ºC fluid temperature*	1461	568	0.008

> "Parker provides us with a more reliable thermal management solution for our modular, high frequency power supply systems ranging from 30 to 360kW."
>
> *– Jason Horn, Stock Equipment Company*

CASE STUDY:

Cooling Stock Equipment's ModuPower™ High Frequency Power Supply Systems

Overview: Stock Equipment Company designs power supply systems for electrostatic precipitators (ESPs), highly efficient filtration devices used for emissions control in coal-fired power plants and other industrial processes. ESPs remove coal-ash particles before they can go up the stack, thereby mitigating the risk of EPA violations, and subsequent plant curtailments and shutdowns. A recent decision by Stock to sell a high frequency Switched Mode Power Supply system (SMPS) named ModuPower™ with its Norwegian partner Applied Plasma Physics allowed Stock to adopt Parker's innovative cooling technology.

"With water cooling, every project required a custom design," said Jason Horn, lead engineer at Stock Equipment. "External water piping to chillers or large external heat exchangers was impractical for most applications. Limited installations also suffered extended down time due to water-cooling issues. We needed a more reliable and scalable thermal management system that fit a standardized design process, was less complex, and eliminated water-cooling issues. Parker's two-phase system uses Evaporative Precision Cooling System to cool. The system is self-optimizing and isothermal; as temperatures rise in the power supply system, more dielectric fluid vaporizes, taking away more heat. Plus Parker's System is modular and scalable like our SMPS, allowing us to standardize the design and easily add more cooling for higher output ratings as needed."

Results: Stock Equipment's high frequency Switched Mode Power Supply systems are now running without failure, minimizing EPA fines. ESP power densities have been increased by over 100% and improved ambient temperature ratings of –40 to +50ºC surpass the competition. Evaporative cooling has also enabled the use of smaller refrigerant pumps and cooling fans for added energy savings.

Markets & Applications

Renewable Energy Solutions

The less weight in the nacelle or power conversion container, the better. Parker's two-phase evaporative cooling system is available in a rack-ready design, or can be configured as a drop-in replacement solution to easily retrofit legacy water or air cooling systems. Parker can cool the full range of wind turbine/power generation systems, including the converter/inverter, reactor, transformer and generator with compelling benefits, including:

- ***Scalability:*** 20 – 300 Kw of cooling
- ***Cost:*** up to 20% system level cost savings
- ***Power Density:*** 2x or more increase in power density
- ***Size and Weight:*** up to 50% smaller/lighter
- ***Safety:*** The fluid used is non-corrosive, does not conduct electricity and needs no freeze protection
- ***Service:*** Hermetically sealed system with 50,000 hr L10 life. No regular service required.
- ***Extended Temperature Rating:*** No de-rating in hot climates

Grid Scale Energy Storage & Power Conversion – Container Solutions (Wind and Solar)

Parker delivers standard containers for grid energy storage for wind and solar farms, configured to customer requirements for battery and power conversion:

- 20' and 40' ISO container configurations
- Adaptive thermal management, to meet individual configuration demands:
  - Air cooling (HVAC)
  - Two-phase evaporative cooling
  - Hybrid mix of both

Hybrid/Electric Industrial Vehicles

Agricultural and construction equipment continue to strive for more ways to increase power and fuel economy through electrification and energy storage of key motor functions. These HE motor drives require aggressive thermal management solutions, and Parker is pleased to deliver these benefits:

- Smaller, more robust cooling systems
- Up to 40% power higher throughput
- Safety: Non conductive fluid is inherently safer for:
  - Ultra capacitors
  - Battery modules
  - IGBT modules

- Greater IGBT reliability and overload protection
- Fluid requires no freeze protection
- Ability to cool all electronics on one loop

Industrial Power Solutions

Medium Voltage Motor Drives and ESP's

The high dielectric strength properties of our coolant make Parker's evaporative cooling systems ideally suited for medium voltage motor drive applications, especially considering the reluctance to using water around high voltage electronics. In addition, our electrically isolated fluid interconnect system allows for modular cold plate designs that more easily isolate high voltage circuits.

- Supports motor drives 1 MW to 4 MW
- Increased power throughput of 40% or more
- Higher reliability
- Field Serviceable – Highly modular IGBT cold plate design

Data Center Solutions

Parker precision cooling systems provide today's stationary and portable data centers with increased processing performance density while reducing overall life cycle costs. Both are achieved through much greater cooling efficiency that air or water cooling.

- Enabling over 2x rack performance density
- Higher reliability
- Reduced energy consumption – no chiller or dedicated HVAC required
- Space savings – up to 50% smaller cooling system footprint
- 20' and 40' container options (up to 350KW per container)

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