

The Use of High-Performance Polymers in HPC and Data Center Applications

Plastics advance as viable, reliable option in liquid cooling systems

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Liquid cooling is emerging as the thermal management approach of choice in high performance computing and data center applications as computing power and densities—and the heat they generate— increase. Liquid cooling manages heat effectively, improves energy efficiency, and today's systems are sufficiently robust to allow use without fear of damaging electronics.

This does not mean systems are fully optimized yet, however. Players in the rapidly evolving high-performance computing ecosystem often have been in the position of deploying with the tools and systems at hand. Examples of this include:

- Use of air-cooling systems, even as they are challenged in their ability to dissipate heat adequately under high utilization rates.
- Use of components originally built for other industries—e.g., heavy-duty ball-and-sleeve connectors used in construction hydraulics—in liquid cooling systems for computing.

The growth of HPC and data center markets has led companies throughout the supply chain to invest R & D dollars to advance liquid cooling operations. Components within the systems, including critical quick disconnects, are targeted for improvement in both form and function. An expanding array of leading edge solutions, innovative approaches and new materials is available to thermal engineers to address urgent needs in liquid cooling. High-performance performance polymers represent one such example.



HIGH-PERFORMANCE POLYMERS CHANGE THE VIEW OF PLASTICS IN LIQUID COOLING

Polymer components in liquid cooling systems are attractive for several reasons: they are lightweight, typically less expensive than metal counterparts, and are impervious to corrosion that can render parts inoperable or introduce debris into flow paths. The challenges with many polymers used to date, however, are their abilities to handle high temperatures and physical stressors without deforming, cracking or creeping. These shortcomings become significant when leaks occur, leading to downtime or damage to equipment.

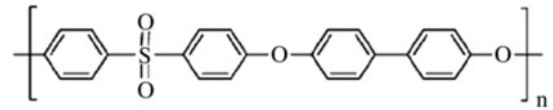
As a result of these deficiencies, both HPC manufacturers and data center operators often default to metal (stainless steel or brass) quick disconnects (QDs) for their liquid cooling needs. All-metal or metal-plastic hybrid options perform well in terms of withstanding rough handling and maintaining material stability for long periods of time. Though durable, all-metal QDs are vulnerable to corrosion. They're also hot to the touch bringing new meaning to hot-swapping of equipment. Systems using them require filtration and periodic fluid maintenance to clear out potential debris due to corrosion.

Hybrid connectors comprised of metal bodies and plastic interior valves work around some of these challenges. These QDs offer the strength, durability and aesthetic characteristics of metal while avoiding corrosion—and subsequent performance degradation—in critical non-spill valve systems.

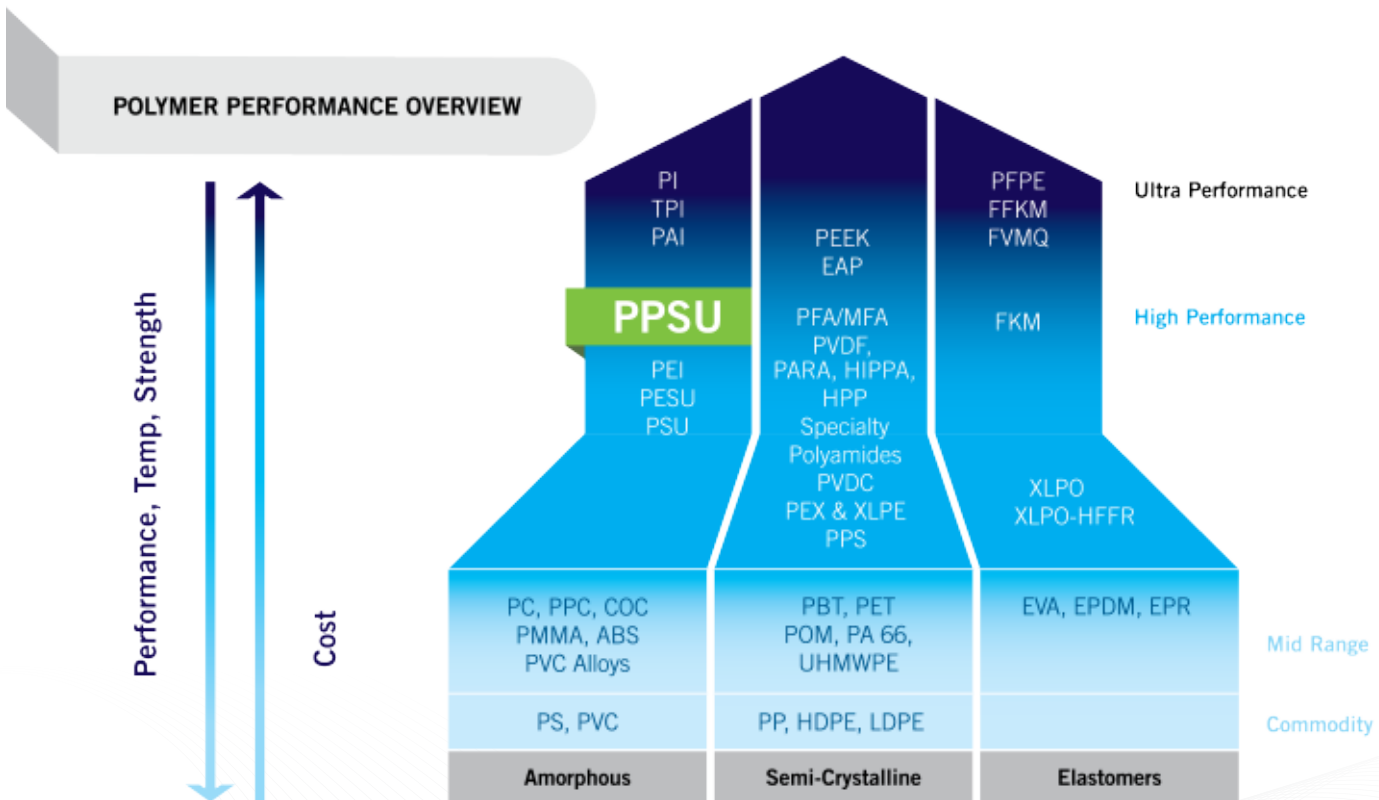
The next evolution in QDs delivers the benefits of plastics—light weight, lower cost, anti-corrosion and condensation-free—with a level of robustness on par with metals. The material associated with these capabilities is polyphenylsulfone, PPSU.

PPSU is comprised of phenylene-based aromatic rings linked by sulfone (SO₂) and ether moieties. This unique chemistry promotes enhanced performance characteristics that are particularly well suited for the demands of liquid cooling applications. Given the emerging prevalence of warm water cooling systems, polymer resistance to hydrolysis is an important factor. Both phenylene sulfone and ether groups being resistant to aqueous hydrolysis significantly increases the overall hydrolytic stability, and in turn reliability, of PPSU in water cooling loops. Polymers with hydrolysable links may be at risk for severe property degradation in hot water environments. Mechanical toughness and impact resistance should also be key considerations for QDs in liquid cooling systems; PPSU is uniquely qualified to provide excellent strength and durability as well as impact resistance due to the phenylene ether groups and the additional biphenylene link not present in other sulfones such as PSU or PES.

A Polyphenylsulfone (PPSU)



Exceptional heat resistance joins polyphenylsulfone’s high flexural and tensile strength, excellent hydrolytic stability and broad chemical compatibility. Repeating sulfone groups reinforce the outstanding thermo-oxidative stability of the polymer. Long-term exposure to a wide range of temperatures is a key consideration of materials selection in liquid cooling systems. Thermal aging effects can be characterized for base resins in a variety of ways, but commonly by reporting a Relative Thermal Index (RTI). This index gives designers a timebound data point at which the material will still have retained 50% of its original properties. Where a commodity plastic such as ABS may have an approximate RTI of 50°C, PPSU yields a mechanical RTI of 160°C after 100,000 hours of continuous exposure.



PPSU CHARACTERISTIC	RELEVANCE
High tensile strength	Resistant to breakage up to 55 MPa or 8000 psi, which is applicable to side load, installation torque and other installation and operating conditions
Excellent heat resistance	Stressed heat deflection temperature up to 205°C, well beyond requirements in most HPC and data center applications UL94 V-0 rated flame retardance
High resistance to environmental stresses	Retains structural integrity when exposed to vibration, humidity and aqueous solutions
Excellent mechanical strength	Handles installation torque without breakage or damage; allows for connection and disconnection as needed without breakage concerns
High dielectric strength and stability	Resists dielectric breakdown in high voltage environments; maintains dimensional stability
Low dissipation factor (DF or $\tan \delta$)	Efficient insulator; low value indicates better dielectric material
Excellent chemical compatibility	Compatible with 3M™ Novec™, DI water, glycol, mineral oils and other engineered fluids
High dimensional stability	Retains its precision shape; low water absorption is ideal for water-cooled systems and humid environments; avoids creep
Lighter weight material	45g (plastic) v 98g of a similarly sized (1/8 inch) metal QD
Good manufacturability and finishing	Allows for streamlined production of useful features like elbows, which fit better in tight spaces (e.g., server racks), as well as leveraging economies of scale with injection molded tooling

In specifying quick disconnects for liquid cooling applications, thermal engineers and data center operators possess a new, robust and reliable option: PPSU QDs. PPSU QDs should be considered when seeking anti-corrosion and durable, reliable performance. CPC's PLQ2 Series delivers these performance requirements along with: optimal flow rates; high-flow/low pressure drop capacity; disconnection under pressure without leaks; a low-profile, ergonomic design allowing one-handed connection and easy installation in tight spaces; and a multilobed seal for redundant protection against leakage and lasting shape retention during extended periods of connection.

CPC offers the industry's first PPSU QD, purpose-built for liquid cooling use in HPC and data centers. Customers rely on CPC engineering expertise to ensure their products and systems deliver long-lasting, efficient, leak-free and reliable performance. With a broad range of solutions including custom products, CPC connectors handle the requirements of even the most demanding applications. For more information visit: cpcworldwide.com/liquid-cooling. Or contact one of our thermal management/liquid cooling engineers at: [Ask Our Engineers](#).

Confidence at every point of connection.

