Location and QD Specification

Liquid Cooling Quick Disconnects – Which Ones, Where and Why

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CONNECTORS FACILITATE LIQUID COOLING SUCCESS

As the demand for more processing power increases, so do power densities and the heat generated by them. To better manage the heat, data centers are adopting liquid cooling at a rapid pace. This is not surprising given that liquid cooling is up to 1,000 times more efficient at moving heat away than air.

Liquid cooling is already used in the world's fastest, most powerful computers. AI now necessitates its use in data centers. Soon it will be found more commonly in university labs, engineering companies and other places that run intense simulations. Liquid cooling systems also manage heat in other rapidly expanding applications like electric vehicle charging stations, medical electronics, telecommunications, and green energy equipment.

Because liquid cooling is now a necessity in a growing range of applications, it is time to overcome the traditional concerns about the proximity of liquid with expensive and sensitive electronics. Quick disconnects (QDs) — in this case, non-spill or "dry break" connectors — are vital in creating reliable cooling systems and supporting the modularity for serviceability that these applications demand.

COOLING AND QDS IN DATA CENTERS

Some of the most complex liquid cooling systems are found in large data centers where literally thousands of QDs enable the use of liquid cooling loops. Coolant distribution units (CDUs), rack manifolds, internal server manifolds, and cold plates are main components within these cooling loops, which are necessary to cool the heat-generating components within the server, namely the central processing units (CPUs) and graphics processing units (GPUs).

The performance requirements for QDs vary by their location within the overall system, so it is important to understand what to look for at each point. This guide covers key considerations for specifying QDs in data centers; however, the same core concepts apply to selecting connectors for use in the cooling loops of many other applications.

FLOW COEFFICIENT AND PRESSURE DROP: KEY CONSIDERATIONS

The first step in QD selection is characterizing each connector set's flow coefficient. Sizing the wrong QD can result in inefficient performance or even product failure, especially if the connector set is smaller than the application requires.

Flow coefficient (Cv) is defined as the flow rate (Q) in U.S. gallons per minute (GPM) with water (specific gravity, or SG, of 1.00) that results in a 1 PSI pressure drop (ΔP) across a connector. (The flow coefficient is unitless.) CPC determines the Cv of any given connector pair (body and insert) with empirical testing using water, observing the pressure drop across a connection at a given flow rate. A formula below is then used to calculate the resulting Cv at each flow rate and averaged to characterize the connector set's performance. The higher the flow coefficient, the better the QD's flow performance.

$$Cv = Q\sqrt{\frac{SG}{\Delta P}}$$

Formula 1.

CDU-TO-MANIFOLD: MANAGING HIGH FLOW RATES

Coolant distribution unit (CDU)-to-manifold connections support modularity and serviceability of the CDUs, particularly when they need to be repaired or replaced.

Connectors in the CDU rack distribution manifolds also are exposed to the highest flow rates — 10 GPM or more. With such high flow rates, the pressure across the entire cooling loop must be high enough to ensure adequate fluid velocity and heat ejection for the liquid cooling system and the application's electronics to work to their full potential.

High flow and low pressure drop are important for the CDU/rack manifold connection as it is one of the highest upstream connection points in the cooling system. Optimizing flow performance upstream delivers high performance and flexibility downstream.

CDU-to-manifold connections are usually the largest connections made with quick disconnects. CPC's largest non-spill QDs, the Everis® LQ10/BLQ10, have a Cv of ~9.3. This means these connectors will have the lowest pressure drop and the highest allowable flow rate.

Connections downstream from the CDU will require less and less flow, allowing for smaller connections along the way. Also, the closer to connection points are to electronics, the greater the need for non-spill performance.

RACK MANIFOLD-TO-SERVER: QDS EASE SERVICE

QDs also connect rack manifolds with individual servers. After connecting the rack's main inlet and outlet to the server's inlet and outlet, fluid flows through the cooling loop rejecting heat coming from the server. At this point, the flow through the manifold is segmented into many different paths, depending on how large the servers are.

QDs in these locations allow for easy and efficient servicing, removal, and replacement of servers in the rack, which is important given the number of potential connection points. For example, if all of the servers are held to 1U in height in a standard 19-inch rack, there could be a multitude of different loops stemming from the manifold. Since these are in parallel, the flow is split as well, resulting in lower flow rates for these connections, though flow rates are very application dependent (more heat necessitates higher flow rates).

Everis® LQ2, LQ4, LQ6, and LQ8 products are commonly used to make rack manifold-to-server connections.

CONNECTOR NAME	NOMINAL FLOW SIZE	CV
EVERIS® LQ2	1/8"	0.37
EVERIS® BLQ2	1/8"	0.37
EVERIS® LQ4	1/4"	1.4
EVERIS® BLQ4	1/4"	1.4
EVERIS® LQ6	3/8"	2.2
EVERIS® LQ6	3/8"	2.2
EVERIS® LQ8	1/2"	6
EVERIS® LQ10	5/8"	9.3

Table 1: Everis® QDs Flow Performance

All the connections mentioned so far are hand-mated—a latching mechanism locks the insert (male) connector into the body (female) connector, securing them together.

Figure 1: At left, color-coded hand-mate Everis(R) LQ6 QDs with latches. At right, blindmate Everis(R) BLQ6 quick disconnects which require an external locking system.

Another connector configuration, blindmate QDs, are commonly seen when a server rack or power conversion unit has a distribution manifold with fluid connections, as well as electrical connections at the back of the tower. Figure 1 shows the difference between hand-mated quick disconnects which are self-locking and blind mate connectors.

Many applications slide blades into the rack so the connection is "blind," thus the name for this style of connector. The servers or power conversion units are typically held in place by a locking mechanism on the front. With blindmate connections, operators just slide the blade or unit into the frame, locking it in, which in turn opens the QD's valves.

Blindmate connections rely on a fine level of alignment for proper function, so sometimes panel-mounting kits that allow for radial, axial, and angular float are used to ensure proper QD alignment.

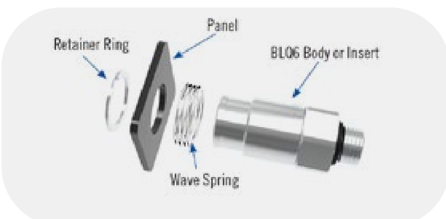

Figure 2: Panel mounting kit for the Everis® BLQ6 that allows for radial, axial, and angular float.

INTERNAL BLADE DISTRIBUTION MANIFOLD: HANDLING TIGHT SPACES

Distribution manifolds for individual servers are typically inside the blade. These manifolds distribute fluid to the individual GPUs, CPUs, or anything else that requires liquid cooling, simultaneously feeding up to eight elements or more. Connections made at the internal distribution manifold usually run to an element, and then back to the manifold's return side. This allows for easy and efficient swapping of CPUs/ GPUs and server maintenance.

Because these connections are within a blade — sometimes even constrained to a 1U height — complex and unique geometries are often required. Smaller spaces mean smaller quick disconnects, which have lower flow rates, so Everis® LQ2 and LQ4 connectors with their high flow rate-to-size ratios are commonly used.

Figure 4: CPU/GPU interconnect engineered solution.

QDs often can be customized to fit. In fact, some of CPC's elbow QDs with a 90° bend were developed in collaboration with a leading supercomputer manufacturer. Figure 3 shows a plastic injection-molded QD for an internal distribution manifold that fits within a 1U server blade. QDs in tight spaces still must deliver the required flow characteristics, which is why engineered solutions are sometimes needed, depending upon the system configuration.

Figure 3: Engineered solution QD used for an internal distribution manifold for a data center application.

CPU/GPU INTERCONNECTS: ENGINEERED SOLUTIONS COMMON HERE

QDs also are commonly found in the interconnects between the CPUs and GPUs. As mentioned before, distribution manifolds within individual servers feed individual elements. In some cases, multiple elements — often the CPU and GPU — have a cooling loop set up in series. This means that one inlet and outlet from the internal distribution manifold is feeding multiple elements within the blade. In this configuration, QDs appear between elements in the blade, not just on the distribution manifold. Space is even more limited, especially if working within a 1U height.

Maintaining solid flow performance in tighter and tighter spaces is a key challenge, so almost everything at this level is an engineered (customized) solution. Figure 4 shows an engineered solution used both for the interconnects between CPUs and GPUs, and as the internal distribution manifold's connector.

IN SUMMARY: SIMPLIFYING THE COMPLEX

Many places within data center cooling systems — and other applications such as edge computing, power conversion, lasers, and medical electronics — benefit from the use of quick disconnects.

Generally, the first step for system engineers is characterizing how much heat must be expelled from the system. Then they determine the appropriate coolant. These steps help define everything else in the cooling loop.

One of the most important requirements is defining the allowable pressure drop across any given loop and its components, including connector sets. After determining all the QD locations, sizing of the connectors is relatively easy. The process usually involves moving from inside of the server to the distribution manifolds and finally to the CDU. Doing this will also help determine the correct pump.

Specifying materials of construction that are chemically compatible with cooling fluids is critical, too. Connector materials should be compatible with the rest of the loop components to avoid galvanic corrosion as much as possible. QDs are made with metal, polymeric, and elastomeric materials. Any degradation of these components due to fluid exposure could lead to leaks in the system.

QDs support modularity, replaceability, and serviceability of all components within liquid cooling systems. Though it can seem like a lot to specify and select the multiple sizes and types of QDs required for successful cooling, CPC application engineers and technologists have deep experience in both fluid management and liquid cooling and are available to offer support, making the specification process easier.

Carefully selecting the right connectors for appropriate size, flow performance, and chemical compatibility will help ensure that liquid cooling loops are reliable and function as designed.

To learn more about CPC connector technologies specifically designed for use in liquid cooling of electronics applications, visit our website or contact us at 1-800-444-2474. Also, see other technical guides and white papers on key topics in liquid cooling such as QD material selection (metal or plastic), chemical compatibility, and flow rate impact: https://www.cpcworldwide.com/Resources-Support/Literature/Liquid-Cooling.

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