

The Secret to Smart Design of Liquid Thermal Management Systems

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In thermal management, liquids rule. From treating injuries to protecting sensitive equipment, fluid-based systems now dominate thermal management for two reasons. First, liquids quickly and cost-effectively pull more heat than fans. Second, they maintain consistent temperatures in systems that require precise temperature control.

of even the most complex and expensive systems.

“While connectors may seem small and insignificant—many are smaller than a person’s thumb—they actually play an important role in successful liquid thermal management,” says Dennis Downs, CPC’s business unit manager for medical and industrial markets. Many leading companies and their R&D, product and industrial designers now regard connectors as a “secret weapon” in gaining a competitive advantage in today’s complex marketplace.

For those who embrace user-centered design—a design process where user requirements drive each stage of the product development process—connectors are essential to creating smart products that employ liquid thermal management systems.

CONNECTORS: PROVIDING A COMPETITIVE EDGE IN THE DESIGN OF TODAY’S LIQUID THERMAL-MANAGEMENT SYSTEMS

Increasingly, R&D, product and industrial designers realize the success of liquid-based thermal management systems depends upon connectors. Why? Because connectors improve the user experience, which 92 percent of respondents to an International Data Group survey ranked as either extremely important or very important. “Other reasons include increased

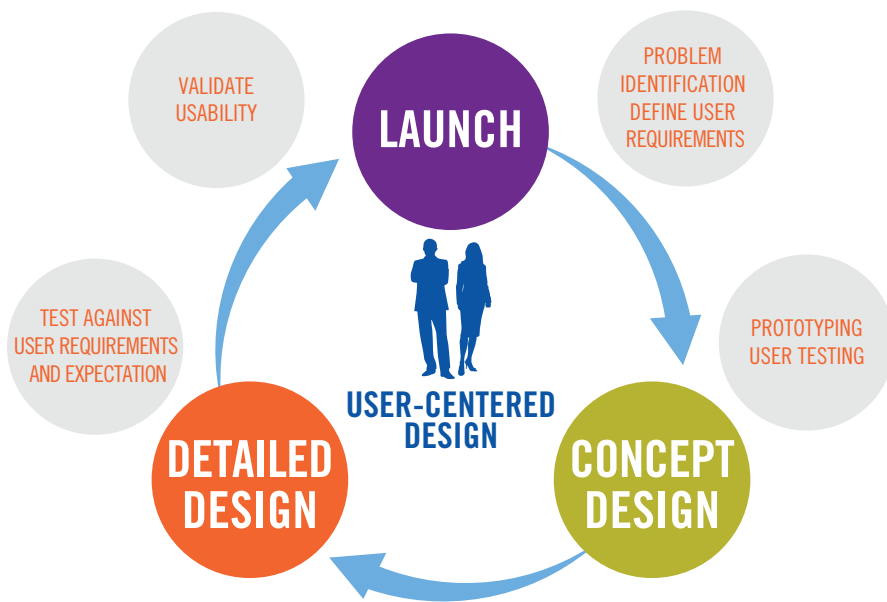


Figure 1: User-centered design incorporates several “circles of proof” throughout the product development lifecycle that confirm that the product meets user requirements and will deliver a superior user experience.

To deliver these key benefits, liquid thermal management systems rely upon one small but critical design component: the connector. In fact, high-quality connectors are fundamental to the successful operation



reliability and decreased maintenance and downtime,” says Downs.

But with so many connection options facing designers and manufacturers, deciding which connector best suits a specific application can be overwhelming. There are literally tens of thousands of off-the-shelf connectors and nearly as many custom options. Some, such as those used in certain medical products, can be disposed, while others, such as those used in mission-critical electronic cooling-systems, must remain connected and drip-free for years on end.

Regardless of how long they are intended to be used, today’s most in-demand connectors generally include the following:

liquid thermal management to constrict blood vessels to help reduce pain, swelling and inflammation, and is often used to help professional athletes recover more quickly from strenuous workouts and demanding games. In addition to reducing swelling, cold therapy also removes lactic acid, which can hinder muscle performance and lead to muscle fatigue.

Ice has long been the cold-therapy method of choice for medical professionals, including surgeons, doctors and trainers. However, these medical professionals are increasingly turning to cold-therapy systems which consist of a “therapy cuff” that fits over a simple cooler with a small pump and a hose that connects the two components together.

The user typically sets the water temperature to 30 to 50 degrees Fahrenheit, with no need for manual temperature adjustment. The system automatically controls the temperature by constantly replacing warmed water with colder water. This process ensures that the injured area is treated with the same cold temperature throughout the therapy session, providing deeper penetration of the therapeutic benefits of cold therapy.

Some cold-therapy systems also add compression to further speed healing. “The patient puts a therapy cuff on the injured area,” explains Downs. “The cuff, which features channels for circulating cold water, automatically and intermittently compresses, then releases. This dual-action helps minimize swelling and promotes tissue repair and healing by increasing blood and oxygen flow to the area.”

Whether used in a hospital room, physical therapy center, practice facility or home

FEATURES

BENEFITS

Non-spill, closed-system design	Ensures drip-free disconnects
User-friendly ergonomic design	Improves usability
Intuitive interface	Minimizes training, reduces errors
Free coupling rotation	Allows tubing to move freely or relax without kinking or leaking
Chemically resistant materials	Provides reliable strength and performance in a range of applications
Audible connection	Guarantees reliable connection
Break-away latch	Ensures intuitive and rapid disconnects
Does not mate to luer fittings	Improves patient safety

**A CLOSER LOOK:
SIX APPLICATIONS OPTIMIZED
BY CONNECTORS**

Connector features and benefits provide cutting-edge advantages to some of today’s most innovative applications, including the six profiled below:

APPLICATION #1: COLD THERAPY

Cold therapy, the type of first aid most often applied after an injury, relies on



Figure 2: Cold therapy device (Inset: DTLTD)

healthcare setting, getting the full benefits of cold therapy requires leak-free circulation so the best systems feature dual-tube connectors such as CPC’s newest connector, the DTLTD Series. The first connector designed specifically for the cold-therapy market, the dual-tube connector comes with a highly desirable feature: the ability to connect and disconnect the tubes independently or simultaneously—with just one push of the connector’s ergonomically designed latch. In addition, an audible “click” makes it obvious when a proper connection has been established.

The, DTLTD connectors feature a leak-free design that prevents cold water from dripping onto an individual, the bed or the floor. This keeps patients both safe and comfortable.

APPLICATION #2: COOL CLOTHING

If you think an asphalt parking lot on a summer day is hot, imagine the surface of a NASCAR racetrack with several dozen cars racing at speeds of more than 150 miles per hour. Now imagine yourself behind the wheel of one of those cars, where interior temperatures can quickly soar upwards of 140 degrees, even on

relatively cool days. If drivers aren’t careful, dehydration, heat exhaustion and even death can result.

In the past, that was a risk drivers had to assume. But no more. Today, an innovative solution is helping drivers—and other professionals who work in environments with extreme temperatures—maintain comfortable and safe temperatures. That solution? Clothing with built-in cooling devices.

Cool clothing typically features three components:

- **A shirt, vest or body suit.** Available in a variety of sizes and styles, these garments come with built-in tubing that circulates cold water in order to reduce body temperature.
- **A pump.** Attached to the tube-lined clothing via an insulated hose and typically housed in a small plastic container that looks like a small beverage cooler, the pump forces cooled water into the tubes and keeps the water circulating.
- **Power.** The most effective cooling, especially for clothing worn more than two hours, requires a source of power. That power can be generated either by wired electricity or batteries. Portable types of clothing, made for shorter periods of wear, rely on gel or ice packs rather than a power source.

Top-rated clothing features connectors such as CPC’s NS4 Series. These connectors feature non-spill valves, making them ideal for situations where even just a few drops of liquid could compromise safety or equipment or the ability to comply with environmental regulations. In addition, soft touch overmold makes them attractive, as well as comfortable in user hands.



Figure 3: Photo of Clothing (Inset: Breakaway Connectors)



Figure 4: Cincinnati Sub-Zero Hypothermia Blanket (Inset: PLC Series)

Another connector, CPC's BreakAway, is also used in cool clothing where the wearer may need to make a clean, fast break at critical moments; for example, a racecar driver who must flee a flaming vehicle. He has no time to reach over to find and depress a latch in order to free himself from his clothing's cooling which is why BreakAway connectors are designed to specifically disconnect quickly, easily and safely when pulled..

APPLICATION #3: HYPOTHERMIA BLANKETS

Hypothermia blankets are another way of regulating body temperature. Sometimes referred to as cooling blankets, these blankets lower a person's internal body temperature. This can be a life-saving measure for individuals with heat stroke, which, if left untreated, can lead to seizures, brain damage and even death. Hypothermia blankets can also be life-saving for those who have suffered cardiac arrest or experience a high fever. By lowering body temperature from its normal 98.6 degrees Fahrenheit to 90 to 93 degrees, the blankets slow the body's functions, thus reducing or even preventing further damage.

Hyperthermia blankets, designed to raise rather than lower body temperature, are also available, as are hypo/hyperthermia models that can both lower and raise body temperature. As with the cool clothing described above, these blankets, such as the

one manufactured by Cincinnati Sub-Zero, feature built-in channels that circulate either cold or hot water.

Thanks to CPC's quick disconnect connectors, patients and their caregivers who use these blankets can—with one push of a latch—simply disconnect the blanket from its water-circulating unit. "There's no need to turn off the unit or the water or to stop the water from flowing some other way, such as by affixing hose clamps," says Cindy Wasmund, Registered Nurse from Cincinnati Sub-Zero Products, Inc. "Instead, the release of the coupling automatically and instantly shuts off all water flow."

As a result, users do not have to remember complicated multi-step processes, drain hoses or wipe up spills. What's more, they never get soaked by unexpected water dripping onto their clothes or spraying across the room.

With CPC's DTLD dual-tube connectors focused on the user experience, two separate fluid lines can run simultaneously into one connector. With its patent-pending latch, the fluid lines connect independently or simultaneously to the DTLD coupling. And because the connector comes with a single thumb latch, users need only one hand to disconnect the loose-form tube sets.

CPC's leak-free dual-tube connectors also allow control of directional flow.

APPLICATION #4: LASERS

According to WebMD, approximately 50 percent of U.S. residents who have a tattoo eventually want it removed. When they do, they often turn to laser tattoo removal, which uses a high-intensity light beam to break up the colors of the tattoo into small particles the body's immune system can absorb.

Regardless of whether tattoo removal occurs in a salon or an established medical practice, the laser's beam generates heat; the larger the beam, the more heat that's generated. And that heat can make the laser's hand piece too hot for operators to hold. Much the same way liquid circulates to cool a blanket, liquid circulates to cool laser handpieces, as well as the handpieces of other aesthetic devices.

Typically these hand-piece devices connect to a main console and swapped out as needed for different procedures. Having the right connector makes changing handpieces, umbilicals and other modular tools simple and fast, improving efficiency and delivery. One popular connector for such devices is the CPC Hybrid Connector, which features a single, easy-to-use twist latch that combines and simplifies the multiple connections—power, fluid, air—needed to operate such devices into a single, simple motion. This not only prevents operators from making time-consuming errors, it also keeps equipment dry and damage free.

“Featuring dry-break technology, CPC's Hybrid Connectors allow product developers such as myself to confidently specify a single off-the-shelf solution to connect air, fluid and electrical,” says Downs. “And because the connectors are made of lightweight plastic, they are ideal for handheld devices that could otherwise strain a technician's hand or arm after only a few hours of work.”

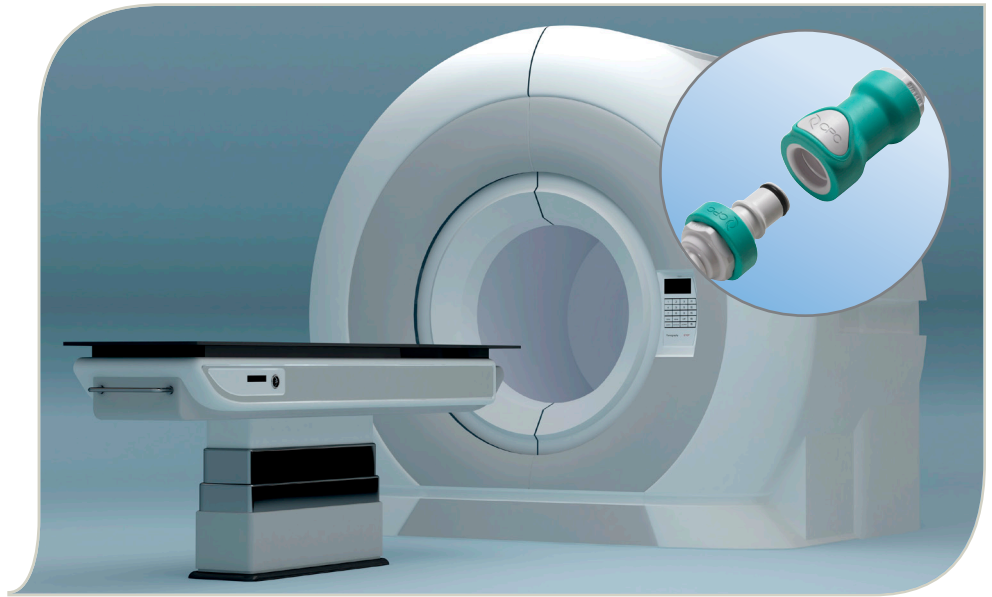


Figure 5: Photo of MRI (Inset: NS6)

APPLICATION #5: MEDICAL IMAGING

Another application that relies on CPC's NS6 Series couplings are powerful MRI scanners. The scanner's critical components—powerful magnets and the scanner's electronics—are cooled to absolute zero (-459.67 degrees Fahrenheit) via liquid hydrogen.

Thermal management couplings which feature non-spill valves. Non-spill valves are ideal for application where even a few drips could compromise patient safety or the safety of the equipment.

Made of plastic, the couplings readily comply with environmental regulations. In addition, they're lightweight, chemically resistant and easy to use. What's more, the non-spill design virtually eliminates spills, minimizing downtime and enhancing operator safety.

APPLICATION #6: LIQUID COOLING OF ELECTRONICS

If you're in business, chances are your very existence depends on electronic equipment and that equipment—everything from phones to appliances to computers—has gotten smaller,

faster and cheaper thanks to transistors. In the 1960s, transistors cost about \$8 each and were about the size of a thumb tip. Today's transistors, on the other hand, cost just a fraction of a cent, and billions fit on a thumb-sized chip.

That's the good news. But there's bad news as well—the amount of heat generated by transistors. This heat must be dissipated quickly to ensure the safety and continued operability of the electronics. Enter liquid cooling. Liquids typically have much higher thermal conductivity than gases. As a result, they are more effective at cooling electronics.

But liquid-cooling systems come with risks, including leakage, condensation and corrosion, any of which can destroy a transistor-dependent medical device, a supercomputer or even an entire data center. Even minor data outages are costly: According to the Ponemon Institute, the average cost for any data center outage is more than \$690,000.

“With such costly problems only a water drip away, you can see why connectors are so important,” says Scott Rosenbalm, senior mechanical



Figure 6: Photo from GatesAir equipment (Inset: LQ6)

About CPC

CPC helps companies and entire industries change the way they think about fluid handling at the critical point of connection. From general-purpose quick connectors, to highly specialized categories like sterile, multi-port, and liquid cooling of electronics, CPC has a connector for every customer's needs. If not, CPC works with its customers to create the perfect custom solution for their fluid handling challenges. Visit cpcworldwide.com to learn more.

engineering, GatesAir, which manufactures market-leading solutions for over-the-air broadcasting and public safety communications.

Power modules are removed for replaced or maintenance only a couple of times a year, so connectors need to be able to remain connected for months on end, then disconnect easily without leaking. “The connector we selected would also have to withstand long-term use because GatesAir transmitters can be upgraded in the field to newer digital standards for extended product life,” adds Rosenbalm.

Leak-free reliability was a primary objective for GatesAir and one of the key reasons its supplier search led to CPC and its new LQ6 Series dripless, quick-disconnect couplings. These couplings feature patent-pending liquid cooling valve technology and a guaranteed closed-system design with a unique automatic non-spill shutoff valve that delivers ultra-reliable dripless disconnects. In addition, the coupling's integral terminations ensure fewer potential leak points, shorter assemblies and faster installations. The result? Increased safety, ease of use and reliability.

There's also another benefit. “We do a lot of our transmitter designs to reduce the cost of ownership for our customers,” says Rosenbalm. “With liquid cooling we can transfer the heat load outside the building,

which helps our customers save on air conditioning expenses,” continues Davis.

THE SIMPLY ELEGANT CONNECTOR THAT MAKES IT ALL POSSIBLE

All of these innovative applications, as well as many others that also use liquids to control temperature, are made possible by a simple, yet very important component: the connector. Leading product developers know that connectors help keep people safe and comfortable and equipment reliable. These factors work together to improve the user's experience.

But with so many connection options to choose from, it is important to not only consider your needs, but also the needs of your users. When selecting connectors, consider integrating the following questions from leading product designers into your design process.



Smart fluid handling to take you forward, faster.



QUESTIONS

KEEP IN MIND



FLOW

What is your required flow and pressure drop?

When calculating, be sure to allow for the effect of shutoff valves and tubing connections.



TUBING

What's the diameter of the tubing you are using?

Be sure to know the inner and outer tubing diameter dimensions.



MEDIA

What media are you using?

The viscosity and corrosiveness of the fluid traveling through the connection can affect fluid flow, as well as the connector itself. Make sure all media are chemically compatible with the connector you choose, as well as all coupling materials, including o-rings, seals and springs.



TEMPERATURE

What is your minimum and maximum temperature range?

Standard ranges are from -40° to 200° Fahrenheit/40° to 93° Centigrade.



PRESSURE

What is the maximum pressure your connector will need to withstand?

Quick-disconnect connectors rated to 250 psi (17 bar) will be able to handle most low-pressure applications.



TUBING CONNECTIONS

What tubing connection are you using?

The most common are hose barb, compression fittings and push-to-connect.



SHUTOFF OPTIONS

Do you need automatic or integral shutoff valves? Single, double or non-spill?

Fluid-filled connectors that don't come with an automatic shut-off could lead to slips and falls.



MOUNTING OPTIONS

How is the connector going to be configured into your application?

The most common configuration ways are via pipe thread, panel mount, in-line or elbow.



EASE OF OPERATION

Do users need a connector that's easy to operate?

Don't forget to think about professionals and non-professional users.



RELIABILITY

Could a misconnection or failure occur? If so, how and how often and what are the consequences?

A misconnection or failed connector in one instance may be a minor inconvenience, while in another, it could be a major disaster resulting in severe injury or even death. And while some industries can tolerate multiple faults, others, such as the healthcare industry, operate under the principle of "safety under single fault conditions." This means that a single fault should not impose the risk of loss of life.



REGULATIONS

Which federal, state and industry regulations must you comply with? Are there any forthcoming regulations to be aware of?



SPECIAL REQUIREMENTS

Do you have any special requirements such as sterilization, NSF listed, USP Class VI approved materials, special packaging, color coding, keying, lot traceability, etc.?

Are there other devices or machines being used in the same environment that may need to be connected? If so, what are they and what are their functions? Taking these devices and machines into account on the front end can save time, reduce costs and improve safety.