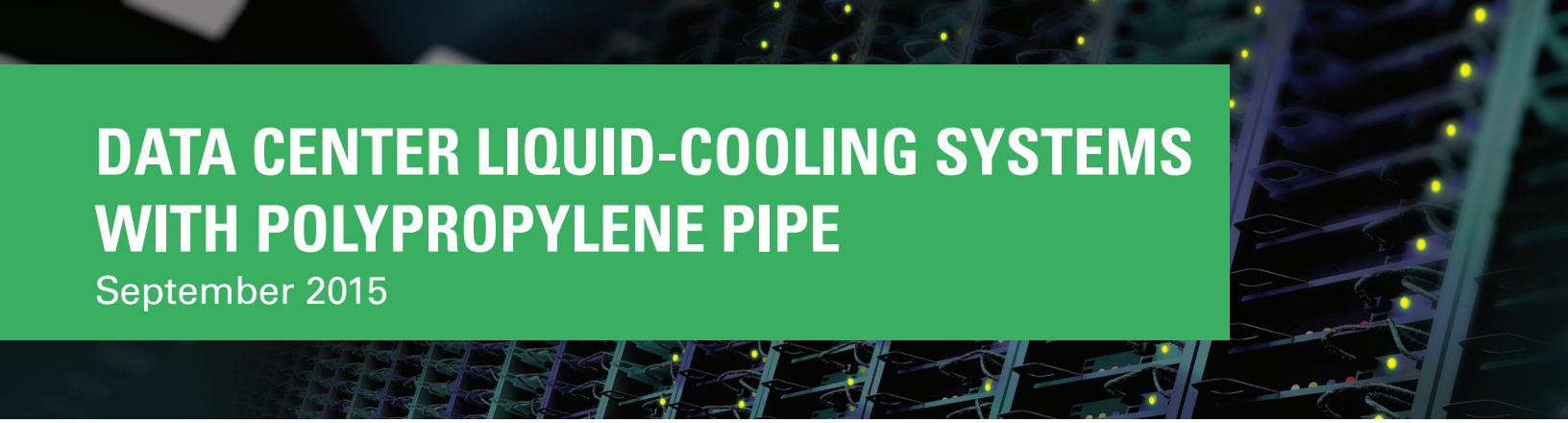


DATA CENTER LIQUID-COOLING SYSTEMS WITH POLYPROPYLENE PIPE

September 2015

Polypropylene-random piping remains leak-free, even under extreme conditions

Whether a Fortune 500 company is storing its annual tax receipts or a dad is saving a video of his kid's first Little League baseball game, data is one of our most precious assets. Everyone storing information—no matter how large or small—relies on data centers to keep their valuables safe and secure. Even cloud-based service providers use data centers to house resources or as a backup to guard data availability during outages.

Unfortunately, data centers aren't indestructible; they are actually almost fragile infrastructures, at the mercy of Mother Nature, fire, power-distribution systems, electric utilities, internal environmental factors and, of course, human error. One of the most significant dangers to data centers is heat.

Data centers house servers, and servers generate heat; the more servers a data center contains, the more quickly it warms up and the greater its potential for overheating. Additionally, data centers aren't only affected by catastrophic meltdowns; a computer's lifespan shortens dramatically when it's kept in an area that is even slightly too warm. Optimal data center temperature depends on the type of hardware being used and its applications, but most data centers operate between 68˚F and 72˚-55˚ at minimum and approximately 80˚ at maximum.

Furthermore, server-room failures are expensive: Hardware must be replaced, and businesses lose revenue while downtime skyrockets. A first-rate cooling system is critical to a data center's health and life cycle as well as any affected company's bottom line.

AIR COOLING VS. LIQUID COOLING

Data centers can be cooled in a number of ways, including via computer-room air-conditioning (CRAC) units, aisle containment, free-air cooling, in-row cooling, airflow monitoring and liquid cooling. All of these cooling solutions have their benefits and disadvantages, of course; however, some options tend to nudge out the competition.

Air-cooling systems have been popular in the past because it seems easier to install a few air-conditioning units or rearrange a server room than set up a liquid-cooling system. But air-cooling systems require specifying raised floors as well as HVAC systems to air condition the entire data center, and obstructions as minute as a sealed opening can significantly impact cooling capacity; additionally, multiple fans create noise pollution, and working in frigid temperatures is never pleasant.

As heat and power densities continuously escalate across developed countries, liquid-cooling solutions become more appropriate. Liquid-cooling systems provide a much higher capacity to dissipate heat: Water is 3,467 times more efficient than air at removing heat. Because they are more efficient, liquid-cooling systems tend to use less energy than air-cooling systems.

While the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) recommends a relative humidity of 40%-55%, higher chilled-water temperatures often avoid humidification problems, bypassing excessive energy use. Liquid-cooling also eliminates thermal stratification, which occurs in air-cooling systems when cold air falls to the bottom of the server rack and hot air rises, increasing air-intake temperatures and, again, energy consumption. Also, high-density heat loads can be clustered into liquid-cooled cabinets, freeing up floor space. Finally, liquid-cooling systems don't demand raised floors or noisy fans.

Water is 3467 times more efficient than air at removing heat.

On the other hand, one of the biggest detractions to liquid-cooling systems is the fear of piping failure. If the pipes spring a leak, the resulting mess will be more than a nuisance. The best way to allay this fear is to specify a leak-free piping system. And in some cases, data center operators resort to double containment type systems that feature a tray underneath piping runs.

BENEFITS AND DRAWBACKS TO PIPING-SYSTEM OPTIONS

Although several piping options can be used for data center liquid-cooling systems, not all of them are entirely suitable. Steel, copper, PVC and PEX piping all can be installed in liquid-cooling systems. However, traditional piping materials use foreign substances—such as glue or solder—or mechanical connections to secure the system's joints, but these bonds ultimately fail.

Data centers are no place for water drips or extra humidity, and both steel and copper can create condensation concerns. Likewise, steel and copper pipes are prone to corrosion and rust, which can induce outright failure. Grooved fittings also introduce the potential for leakage. Additionally, cleanliness is critical to the health of servers, computers and other information-technology (IT) equipment; contaminants can lead to overheating, corrosion or mechanical failure.

Unfortunately, the process of welding or soldering steel or copper pipe introduces fumes and particles into the data center environment; open flames have the potential to set off fire alarms and sprinkler systems, resulting in at least havoc and downtime, if not total collapse of the data center. As commodities at the mercy of the metals markets, steel and copper can be very expensive, especially for large projects.

Sizeable steel and copper pipes are also extremely heavy, can slow workers down, cause injuries on the job, and require heavy machinery for installation.

Many traditional plastic piping systems are prone to cracking or breaking when exposed to extremely cold temperatures or even if they are simply bumped, stepped on or mishandled. Also, systems connected via glue risk adhesive overflow that potentially could clog data center hardware. Additionally some plastics systems cannot be recycled, and others have a permeable membrane that can allow contamination of the piping system. Systems connected via crimping also require intense attention to detail and a steady hand if the liquid-cooling system is to remain leak-free. Any time there is a transition from one material to another, you have the potential for a leak.

PP-R SYSTEMS A STRONG ALTERNATIVE

Comparatively new in the piping arena are polypropylene-random (PP-R) piping systems. Made of fusible thermoplastic, PP-R piping doesn't corrode, so it won't wear out, weaken or clog, even after a few years. Piping systems can be expensive and difficult to replace,

but durable PP-R piping systems survive for decades with 60-year expected lifespans.

A long-lasting solution for non-potable applications such as liquid-cooling systems, the material doesn't react with water or most dissolved chemicals, so it won't scale or erode—problems that cause the majority of long-term piping failures. Additionally, the piping systems are completely free of heavy metals and toxic chemicals; they also are hydrophobic—meaning they repel water from their surfaces—so they will not leach any trace chemicals.

PP-R piping has natural insulation properties; its inherent R-value of roughly 1 (depending on pipe size and diameter) can help reduce the amount of insulation necessary for a liquid-cooling system depending on operating parameters. This can help save valuable data center space as well as upfront insulation and installation costs.

Because of its natural insulation, PP-R piping is less likely to be affected by condensation, although it's essential to consult with the manufacturer to account for condensation. Tough and flexible, PP-R piping can resist physical impact and stress even at low temperatures. Some PP-R piping systems also have a multilayer faser (MF) layer that improves impact resistance and reduces linear expansion and contraction by about 75% compared with other plastics.

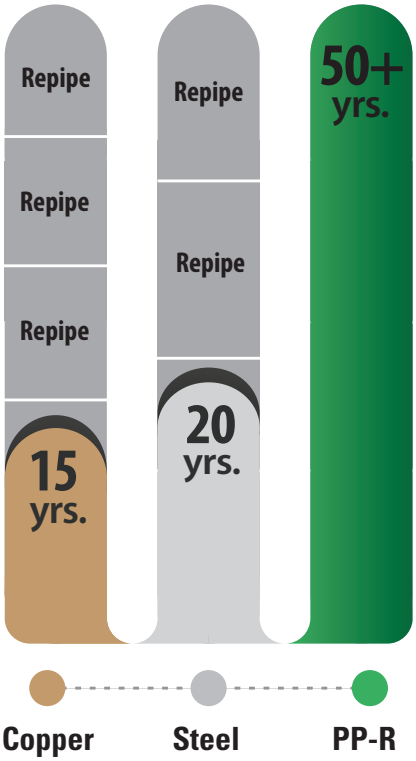
PP-R piping uses reliable heat fusion to form connections; heat fusion bonds both sides of a joint into a single, homogenous material without the use of chemicals or mechanical connections. This eliminates systematic weaknesses and potential fail-points or leak paths in the pipe.

The strong and flexible heat-fusion connections, combined with the piping's resistance to corrosion and abrasion, help ease leakage

concerns. Further, heat fusion doesn't require an open flame, so hot-work permits aren't necessary and fire-protection systems aren't at risk of triggering in the delicate data center environment. Because the heat-fusion method is safe—with less potential for danger than welding or soldering—and no VOCs are released during the process, PP-R systems can be built in a working data center environment with almost zero downtime.

Whether installers are veterans or novices trying out heat fusion for the first time, PP-R piping systems are simple to put together. Able to fabricate seamless connections quickly, heat fusion can take less time than welding, gluing or crimping, and PP-R piping is much more forgiving than many other kinds of pipe. PP-R piping systems can be prefabricated on or off-site, helping the project progress even faster.

Additionally, PP-R piping weighs 75%-80% less than its metal counterparts, making it easier and faster to transport and install, especially in tight spaces or on hangers. Its light weight also means PP-R piping is less likely to cause jobsite exhaustion or injuries.



PP-R piping systems are sustainable and environmentally friendly. PP-R is reasonably clean to manufacture; it requires only two steps of refinement after petroleum cracking. Only 3% of petroleum is used for plastics production, so PP-R has a much lower impact on the earth than the mining and smelting operations used to create metals. Also, PP-R piping systems are fully recyclable, so the polypropylene is never wasted.

Because PP-R doesn't corrode or scale, the piping systems typically outlast the buildings they are installed in, and their heat-fused connections last even longer without leaks or maintenance. Additionally, PP-R piping systems can contribute indirectly to Leadership in Energy and Environmental Design (LEED) certification credits.

Some PP-R manufacturers even offer a 10-year multimillion dollar insurance policy or warranty, providing date center operators an added layer of protection and peace of mind.

CONCLUSION

Liquid-cooling systems are becoming more and more mainstream as data center densities skyrocket. These systems support faster overall IT running speeds and produce quieter, more inhabitable environments. Although stability and possible leakage were previously the main concerns for engineers specifying liquid-cooling systems, PP-R piping systems have been proven to be a durable, leak-free answer.