

DATA CENTER LIQUID-COOLING SYSTEMS WITH POLYPROPYLENE PIPE

Polypropylene piping remains leak-free, even under extreme conditions

Data is one of our most precious assets. Everyone storing digital 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 power outages.

Unfortunately, data centers aren't indestructible; they are actually almost fragile infrastructures, at the mercy of Mother Nature and at risk of fire, faulty power-distribution systems, unpredictable electric utilities, internal environmental factors and, of course, human error.

Of all the dangers data centers face, one of the most significant 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



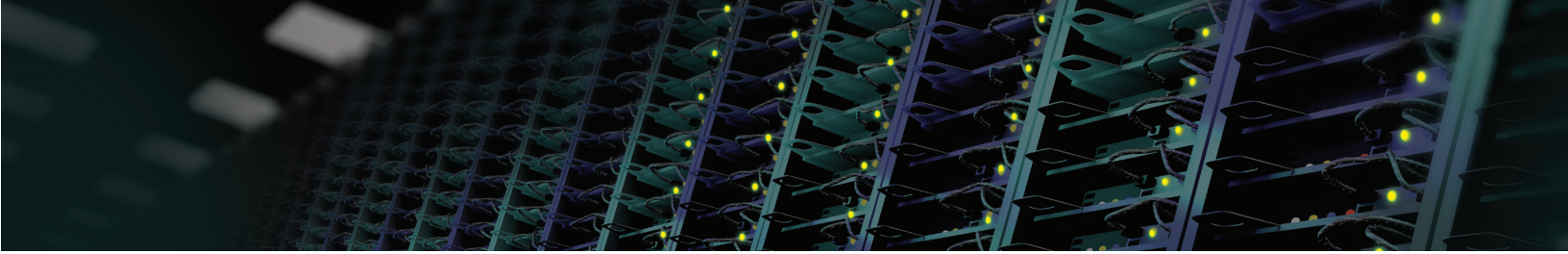
Depending on size and wall thickness, polypropylene pipe can weigh up to 70% less than carbon steel pipe.

type of hardware being used and its applications, but most data centers operate between 68°F and 72°F — 55°F at minimum and approximately 80°F at maximum.

Furthermore, server-room failures are expensive: Hardware must be replaced, and the resulting downtime causes businesses to lose revenue. Therefore, 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



Clean, durable polypropylene can be fabricated in virtually any configuration to meet the specific needs of any data center.

(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 to set up a liquid-cooling system. However, air-cooling systems require specifying raised floors as well as HVAC systems to 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.

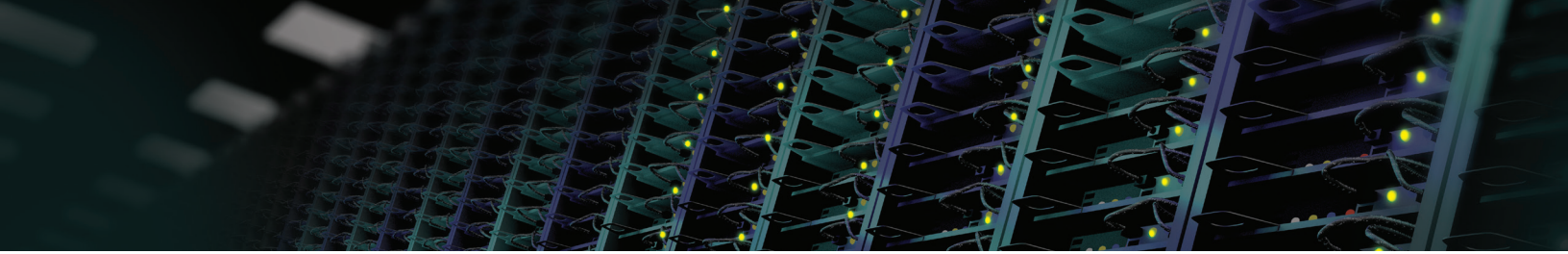
While the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) recommends a relative humidity of 40% to 55%, higher chilled-water temperatures often avoid humidification problems, bypassing excessive energy use. Liquid cooling also eliminates thermal stratification, which 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.

On the other hand, one of the biggest detractors 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, and 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 increase 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.

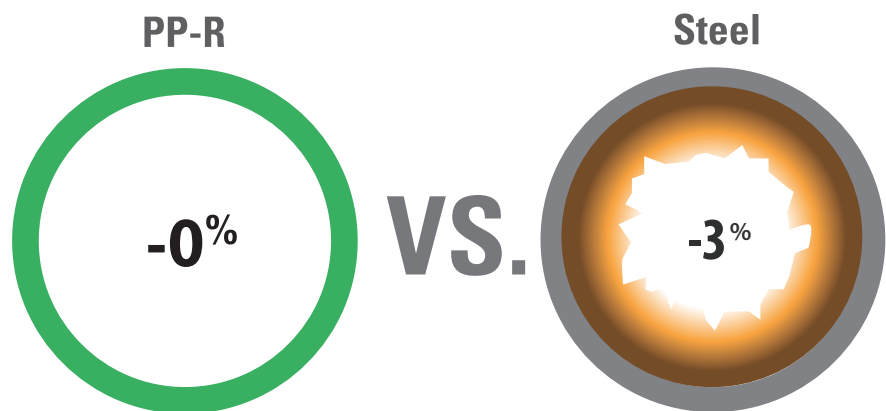
Another mark against metal pipe is that the process of welding or soldering steel or copper pipe introduces fumes and particles into the data-center environment, and open flames have the potential to set off fire alarms and sprinkler systems — resulting in at least havoc and downtime, if not total collapse 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 also are 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

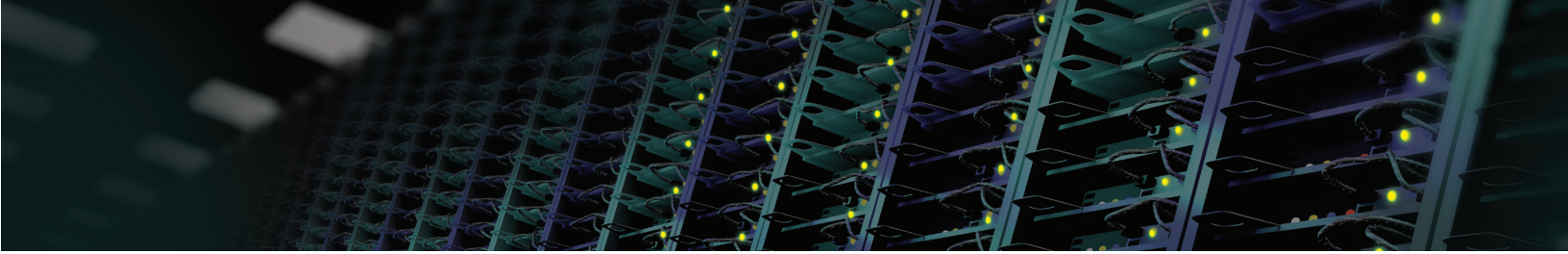
even if they are simply bumped, stepped on or mishandled. Also, systems connected via glue risk adhesive overflow that potentially could clog data-center hardware. Additionally, some plastics systems cannot be recycled, and others have a permeable membrane that can allow contamination of the piping system. 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.



Polypropylene pipe is hydrophobic and will never scale and corrode the way metal pipe does.



As a hydrophobic material, polypropylene pipe does not suffer from reductions in flow caused by scaling the way steel pipe does.



Socket fusion (shown here) is one method of heat-fusing polypropylene pipe and fittings.

PP SYSTEMS A STRONG ALTERNATIVE

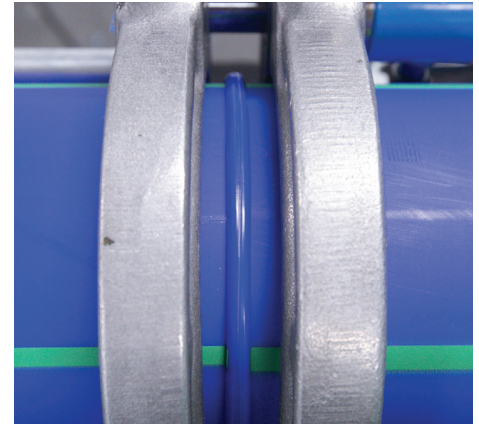
Comparatively new in the piping arena are polypropylene (PP) piping systems. Made of fusible thermoplastic, PP piping doesn't corrode, so it won't wear out, weaken or clog, even after years of service. Piping systems can be expensive and difficult to replace, but durable PP piping systems survive for decades with 50-year expected lifespans.

A long-lasting solution for non-potable applications such as liquid-cooling systems, the PP 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 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 costs and installation.

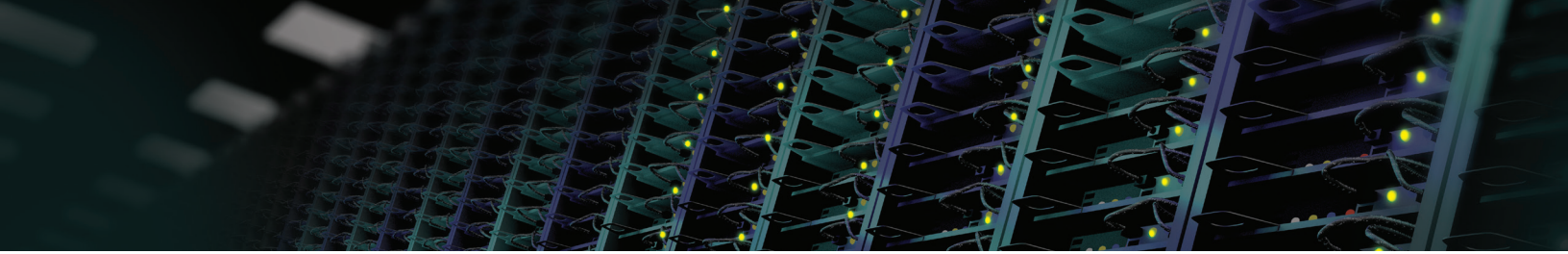
Because of its natural insulation, PP piping is less likely to be affected by condensation, although it's essential to consult with the manufacturer to account for condensation. Tough and flexible, PP piping can resist physical impact and stress even at low temperatures. Some PP piping systems also have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



A properly executed heat-fusion on polypropylene pipe creates a single piece with no leak paths.

PP 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 systemic 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 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 piping systems are simple to put together. Able to fabricate seamless connections quickly, heat fusion takes less time than welding, gluing or crimping, and PP piping is much more forgiving than many other kinds of pipe. PP piping systems can be fabricated on or off-site, helping the project progress even faster.

Some manufacturers also offer fabrication services that allow for intricate work to be performed and the spools shipped directly to the jobsite, saving on labor times and condensing timeliness.

Additionally, PP piping weighs up to 75% 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 piping is less likely to cause jobsite exhaustion or injuries.

PP piping systems are sustainable and environmentally friendly. PP is clean to manufacture; it requires only two steps of refinement after petroleum cracking. Only

3% of petroleum is used for plastics production, so PP has a much lower impact on the Earth than the mining and smelting operations used to create metals. Also, PP piping systems are fully recyclable, so the polypropylene is never wasted.

Because PP doesn't corrode or scale, the piping systems typically outlast the buildings they are installed in, and their heat-fused connections last as long as the pipe itself, without leaks or maintenance. Additionally, some PP piping systems can contribute to Leadership in Energy and Environmental Design v4 (LEED v4) certification credits.

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


CONCLUSION

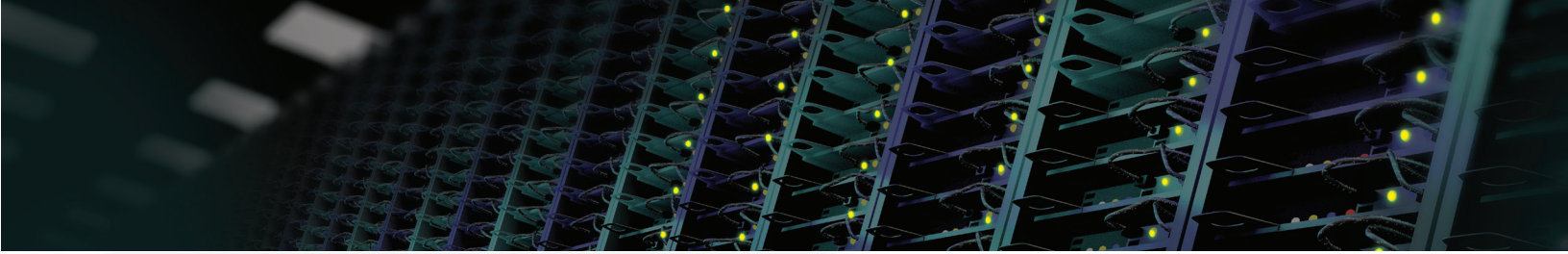
Liquid-cooling systems are becoming more and more mainstream as data-center densities skyrocket. These systems



Polypropylene can be fabricated into long, seamless assemblies without welding, gluing, crimping, or introducing VOCs into the data center environment.

support faster overall IT running speeds and produce quieter, more inhabitable environments.

Although stability and possible leakage previously were the main concerns for engineers specifying liquid-cooling systems, PP piping systems have proved to be a durable, leak-free answer. Several extremely high-profile data centers throughout the U.S. and Canada have come to rely on this proven piping technology. 



PIPE MATERIAL	PP	COPPER	STEEL
Impact Resistant	✓	✓	✓
Chemical Resistant	✓	○	○
Abrasion Resistant	✓	✗	✗
Scale Resistant	✓	✗	✗
Corrosion Resistant	✓	✗	✗
Nontoxic	✓	✗	✗
Nontoxic combustion products	✓	✓	✓
Resists chemical leaching into water	✓	○	○
50-year rating on both pipe and fittings	✓	✗	✗
CONNECTIONS AND FITTINGS			
Leak-proof connections	✓	○	✗
No foreign material (solders)	✓	✗	○
Joints as strong as the pipe itself	✓	✗	○
Fusion outlet (saddle) and other low cost fittings	✓	○	✗
Nontoxic connections	✓	✗	✗
OTHER FEATURES			
Controlled thermal expansion	✓	✓	✓
Recyclable	✓	✓	✓
Opaque to avoid microbiological growth	✓	✓	✓
Inherent R-value	✓	✗	✗
Resistant to water hammer	✓	✗	✗
No open flames	✓	○	○
Connections usable in less than 1 hour	✓	✓	✓
Does not easily sweat	✓	✗	✗
Stable competitive pricing	✓	✗	○
Environmentally friendly piping system (LEED v4 credits)	✓	✗	✗
Large diameters 20mm up to 630mm OD	✓	○	✓
✓ = Excellent ○ Sometimes ✗ Not Recommended			