APPLICATION SERIES

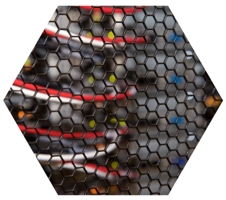
PROCESS COOLING AND DATA CENTRES

A data centre is a large facility that houses many computer servers and other associated hardware and networking equipment. Its primary purpose is to store, manage, process, and distribute large amounts of data.

Data centres are designed to provide high levels of reliability, availability, and security for the information technology (IT) infrastructure of organisations. They typically feature redundant power and cooling systems, backup generators, fire suppression systems, and physical security measures to ensure uninterrupted operation and protection of the equipment housed inside.

Data centres play a critical role in the functioning of modern businesses and organisations, as they enable the storage and processing of vast amounts of data that are used to support critical business processes, applications, and services. They are used by a wide range of organisations, including businesses, government agencies, universities, and research institutions.






What is the Optimum Temperature for Data Centres?

The optimum temperature for data centres is generally considered to be between 18 and 27 degrees Celsius (64 and 80 degrees Fahrenheit).

However, the specific optimal temperature range for a data centre may depend on several factors, such as the type of equipment being used, the density of the equipment, and the location of the data centre. Some newer equipment can tolerate higher temperatures, and some organisations may choose to operate their data centres at higher temperatures to save on cooling costs.

It is also important to note that maintaining a consistent temperature level is critical for data centre performance and reliability. Sudden changes in temperature can cause hardware failures or data loss. Therefore, data centre operators typically employ sophisticated cooling control systems to ensure a stable and controlled environment for their equipment.

The top operating temperature for data centres can vary depending on factors such as equipment specifications, cooling capabilities, and environmental conditions. However, the generally accepted upper limit for data centre operating temperatures is around 40 degrees Celsius (104 degrees Fahrenheit). While it is technically possible to operate data centres at such elevated temperatures, it requires careful planning and implementation to ensure the reliability and performance of the equipment. Some key considerations include:

- ***Thermal management:***
  - Effective thermal management becomes crucial in high-temperature environments. It involves using advanced cooling techniques, such as liquid cooling, rear-door heat exchangers, or direct liquid immersion cooling to remove heat efficiently from the server equipment.
- ***Equipment selection:***
  - It is important to choose server hardware and components that are designed to operate reliably at higher temperatures. Manufacturers offer specialised equipment that can withstand and perform optimally under elevated temperature conditions.
- ***Airflow management:***
  - Proper airflow management within the data centre is critical. This includes optimising the layout of racks, arranging hot and cold aisles, and ensuring that airflow is directed properly to remove heat from the equipment. Hot aisle/cold aisle containment strategies can be employed to prevent hot and cold air mixing and improve cooling efficiency.

What is the Optimum Temperature for Data Centres?

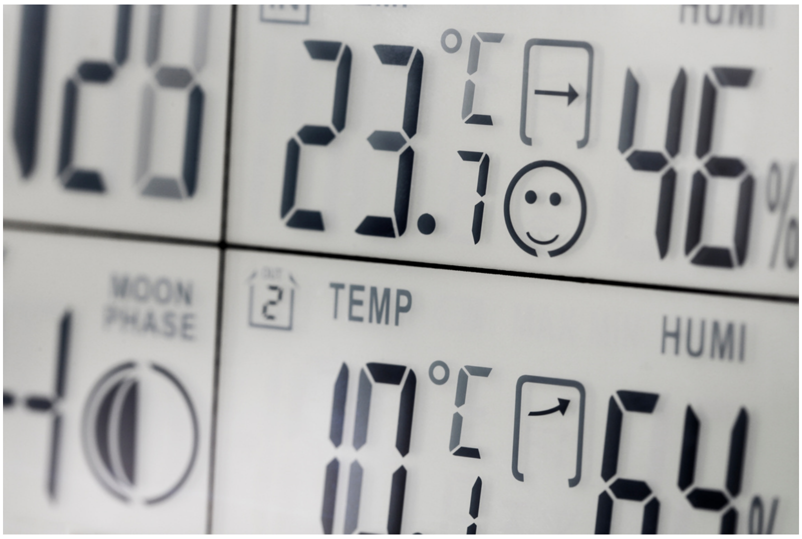
- ***Monitoring and Controls***:
  - Robust monitoring systems should be in place to continuously measure and analyse temperature and humidity levels within the data centre. Automated controls and alert systems can help to maintain the optimal environment and provide early warnings of any potential temperature-related issues.
- ***Backup Systems***:
  - Higher temperatures can increase the risks of equipment failures and downtimes. Redundancy and backup systems including power supply, cooling, and data backups, are essential to ensure uninterrupted operations and minimise the impact of any potential failures.
- ***Environmental Factors***:
  - The data centre location and local environmental conditions play a significant role. Factors such as ambient temperature, humidity, and dust levels need to be considered when designing and operating data centres in high-temperature environments.

It is important to note that operating data centres at higher temperatures can potentially impact the lifespan of equipment and increase the risk of hardware failures. Therefore, thorough planning, proper infrastructure, and continuous monitoring are essential to maintain reliability and mitigate associated risks.

Why do Data Centres Need Process Cooling Equipment?

Data centres generate a significant amount of heat due to the large number of servers and other computing equipment that are housed in a relatively small space. The heat generated by the equipment can cause damage to the hardware and lead to system failures if not properly managed.

Process cooling equipment is necessary to maintain a stable temperature and humidity level within the data centre. This helps to prevent equipment overheating, which can cause system downtime and data loss. Cooling systems also help to improve the efficiency of the equipment, as many servers and other computing devices are designed to operate within a specific temperature range.



There are various types of process cooling equipment that can be used in data centres, including air-based cooling systems, liquid-based cooling systems, and hybrid systems that use both air and liquid cooling. These systems may include components such as chillers, pumps, cooling towers, heat exchangers, and fans, among others.

Air Cooling or Water Cooling?

Deciding between liquid or air cooling in data centres depends on several factors, including the specific needs and requirements of the data centre, the equipment being used, and the availability of resources such as water and energy.

Air cooling is a simpler and more traditional method of cooling, where cool air is circulated through the data centre to remove heat from the equipment. Air cooling systems are generally less expensive to install and operate than liquid cooling systems, and they require less maintenance. They are also a good choice for data centres with lower power densities and less heat-generating equipment.

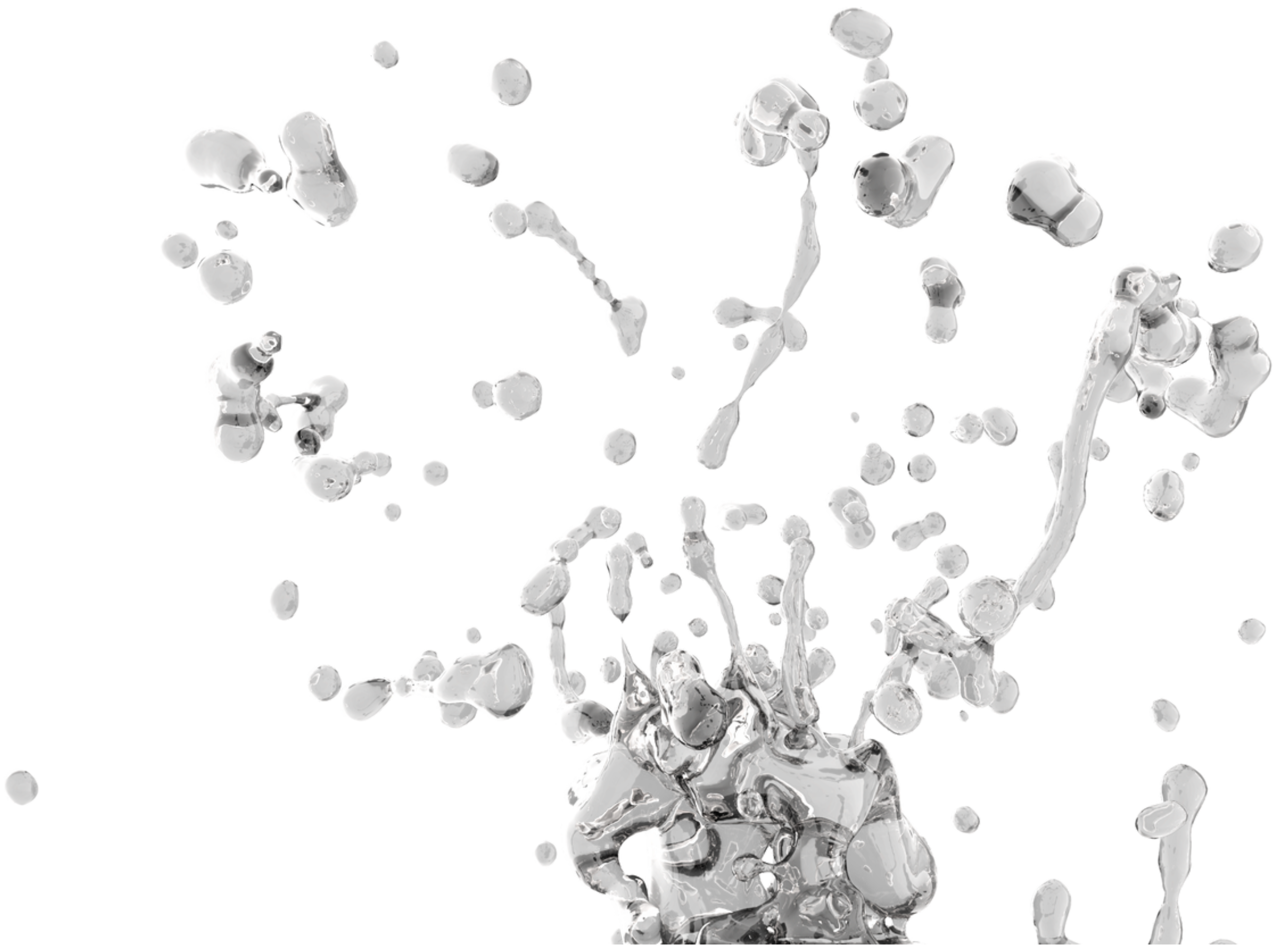
Liquid cooling is a more complex and specialised method of cooling, where a liquid heat transfer fluid is circulated through the data centre to remove heat from the equipment. Liquid cooling systems are more expensive to install and operate than air cooling systems, and they require more maintenance. However, there has been a move towards liquid cooling in data centres in recent years for several reasons:

- ***Noise reduction***:
  - Liquid cooling systems can be quieter than air cooling systems, as they do not require large fans to circulate air. This can be particularly important in environments where noise levels must be kept low, such as research facilities or medical centres.
- ***Energy efficiency***:
  - Liquid cooling systems are often more energy-efficient than air cooling systems, as they can operate at higher temperatures and require less energy to move the heat transfer fluid through the system. This can result in significant cost savings for data centre operators.
- ***Increased power density***:
  - Modern data centre equipment, such as high-performance computing (HPC) clusters and artificial intelligence (AI) systems, generate a significant amount of heat and require a higher power density than traditional equipment. Liquid cooling can remove the heat more efficiently than air cooling, allowing for higher power density and more efficient use of space.

Air Cooling or Water Cooling?

- ***Space optimisation***:
  - Liquid cooling systems can often be more compact than air cooling systems, as they can be designed to fit within racks, or directly onto the equipment being cooled. This can free up valuable floor space in the data centre, allowing for more equipment to be installed.
- ***Futureproofing***:
  - Liquid cooled systems are seen as a futureproof solution, as they can be adapted to meet the changing needs of modern data centre equipment. As equipment becomes more power-hungry and generates more heat, liquid cooling can provide a scalable and efficient solution.

The decision to use liquid or air cooling in a data centre depends on the specific needs and requirements of the organisation. Data centres with lower power densities and less heat-generating equipment may find air cooling to be a more cost-effective and practical solution, while data centres with higher power densities and more heat-generating equipment may benefit from the increased efficiency of liquid cooling. Ultimately, the best approach will depend on a careful evaluation of the specific needs, costs, and benefits of each cooling method.



Immersion Cooling

Recirculating chillers can be used in immersion cooling systems to remove heat from the liquid heat transfer fluid that is used to directly cool the IT equipment.

In an immersion cooling system, the IT equipment (such as servers or GPUs) is submerged in a non-conductive heat transfer fluid that directly absorbs the heat generated by the equipment. The heat transfer fluid then flows through a closed loop system to a heat exchanger, where the heat is transferred to a primary water circuit that is circulated to a recirculating chiller.

The recirculating chiller cools the heat transfer fluid within the primary water circuit to a specific temperature and circulates it back to the heat exchanger, where it removes the heat from the heat transfer fluid in the immersion cooling system. The fluid within the primary water circuit is then recirculated back to the chiller for further cooling.

The use of a recirculating chiller in an immersion cooling system provides several benefits. It allows for precise temperature control of the secondary coolant, which can improve the efficiency of the cooling system. It also allows for the use of high-density IT equipment that generates a significant amount of heat, as immersion cooling can provide more efficient cooling than traditional air- or water-cooling methods.

Rack Mounted Solutions

Rack mounted chillers are recirculating chillers that are designed to be mounted directly onto a server rack in a data centre. They are used to provide localised cooling to high-density IT equipment, such as servers, storage systems, and networking devices.

Rack mountable chillers are typically compact and lightweight, with a slim profile that allows them to fit seamlessly into a server rack. They are designed to provide efficient and reliable cooling to IT equipment, with precise temperature control and a low noise level.

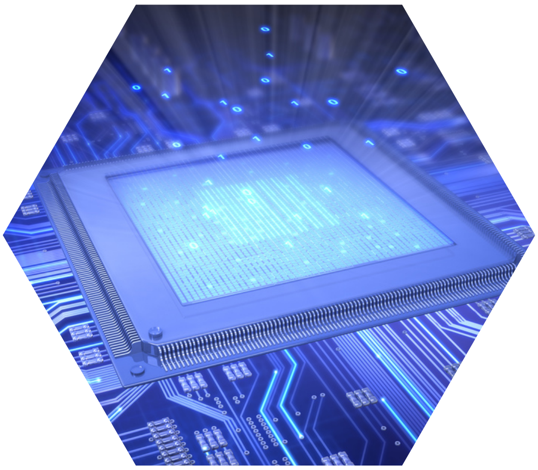
One of the main advantages of rack mounted chillers, is that they provide localised cooling to the IT equipment, which can help to reduce the overall cooling load of the data centre. This can result in improved energy efficiency and lower operating costs.

Rack mountable chillers can be designed with a variety of features and options to meet the specific cooling requirements of the data centre. For example, Applied Thermal Control have a variety of cooling capacities, ranging from 0.5kW to 1.9kW depending on the size and density of the IT equipment.

They may also have advanced control systems that can monitor and adjust the coolant temperature, flow rate, and other parameters to optimise performance and reduce energy consumption.

Direct-to-Chip Cooling

Recirculating chillers can be used in chip cooling by circulating a heat transfer fluid (such as water or a water-glycol mixture) through a closed-loop cooling system to remove heat from the chip.



The chiller cools the heat transfer fluid to a specific temperature and circulates it through the cooling system. The heat transfer fluid absorbs heat from the chip and carries it back to the chiller, where it is cooled and recirculated back to the chip.

The cooling system can be designed in several ways, depending on the specific application and requirements. In some cases, the heat transfer fluid may be circulated directly through the chip or the heat sink. In other cases, a cold plate may be used to transfer heat from the chip to the coolant.

Recirculating chillers can be particularly effective for cooling high-performance computing clusters and other high-density chips that generate a significant amount of heat. They can also be used in applications where a precise and stable heat transfer fluid temperature is required, such as in medical equipment or research facilities.

In addition to chip cooling, recirculating chillers can also be used for other cooling applications in the data centre, such as the cooling of servers, storage systems, and other equipment. They can be designed to be energy-efficient and environmentally sustainable, using technologies such as variable-speed compressors and renewable energy sources like solar or geothermal power.

Passive Cooling in Data Centres

Passive cooling is an approach to cooling data centres that relies on natural or low-energy methods to dissipate heat without the use of mechanical equipment such as fans or pumps. It aims to minimise or eliminate the need for active cooling systems, reducing energy consumption and operational costs. Here are some common techniques used in passive cooling for data centres:

Airflow Management | **Free Cooling** | **Heat Exchanger** | **Building Design** | **Thermal Storage**

- ***Airflow Management***:
  - Effective airflow management is crucial in passive cooling. It involves optimising the data centre layout to establish proper hot and cold aisle configurations, using containment systems to prevent hot and cold air mixing, and ensuring adequate ventilation for natural air circulation. This allows for efficient heat dissipation through convection.
- ***Free Cooling***:
  - Free cooling takes advantage of lower outdoor temperatures to cool the data centre without relying on mechanical cooling. By using outside air as a cooling source, data centres can reduce or eliminate the use of air conditioning units during cooler periods. This technique is particularly effective in regions with favourable climate conditions.
- ***Heat Exchangers***:
  - Heat exchangers facilitate the transfer of heat from the data centre environment to an external medium, such as water or air. They can be used to remove heat from the data centre and transfer it to another location where it can be dissipated more efficiently. Heat exchangers can utilise natural convection or operate in conjunction with a cooling tower or other passive cooling methods.
- ***Building Design***:
  - Passive cooling can be incorporated into the data centre's building design. Features like reflective roofs, proper insulation, shading elements, and natural ventilation systems can help to reduce the impact of external heat gain and enhance natural cooling mechanisms.
- ***Thermal Storage***:
  - Thermal storage systems can store excess thermal energy during off-peak periods and release it during peak cooling demand. This allows for better management and utilisation of cooling resources without relying solely on active cooling systems.

Passive cooling techniques offer several benefits, including reduced energy consumption, lower operational costs, and enhanced sustainability. However, their effectiveness can depend on factors such as climate conditions, building design, and equipment requirements. It is important to carefully assess and implement the appropriate passive cooling strategies based on the specific needs and constraints of the data centre.

Heat Transfer Fluids Used in Data Centres

Recirculating chillers in data centres are typically used with heat transfer fluids to provide efficient and effective cooling. The heat transfer fluid is circulated through a closed loop system to remove heat from the equipment and carry it back to the chiller for cooling.

There are several types of heat transfer fluids that can be used with recirculating chillers in data centres, depending on the specific application and requirements. Some of the commonly used heat transfer fluids include:

- Water
- Glycol
- Oils

Water

Using water as a heat transfer fluid in data centre cooling systems has the following benefits:

- ***High specific heat capacity***:
  - Water has a high specific heat capacity, which means that it can absorb and retain a significant amount of heat before reaching its boiling point. This makes it an effective heat transfer fluid for removing heat from data centre components.
- ***Abundance and accessibility***:
  - Water is readily available and affordable compared to other heat transfer fluids. It is easy to source and can be supplied through existing water infrastructure, reducing the costs associated with specialised fluids.
- ***Non-flammable***:
  - Unlike some other heat transfer fluids, water is non-flammable, which significantly reduces fire hazards in the data centre. This makes it a safer option for cooling sensitive electronic equipment.
- ***Environmentally friendly***:
  - Water is an environmentally friendly choice as a heat transfer fluid. It is non-toxic and can be easily treated and recycled, minimising the impact on the environment.
- ***Compatibility***:
  - Water is generally compatible with a wide range of materials commonly used in cooling systems, such as pipes, pumps, and heat exchangers. It reduces the risk of material degradation or incompatibility issues.

Heat Transfer Fluids Used in Data Centres

Water

However, the use of water does have some drawbacks to consider:

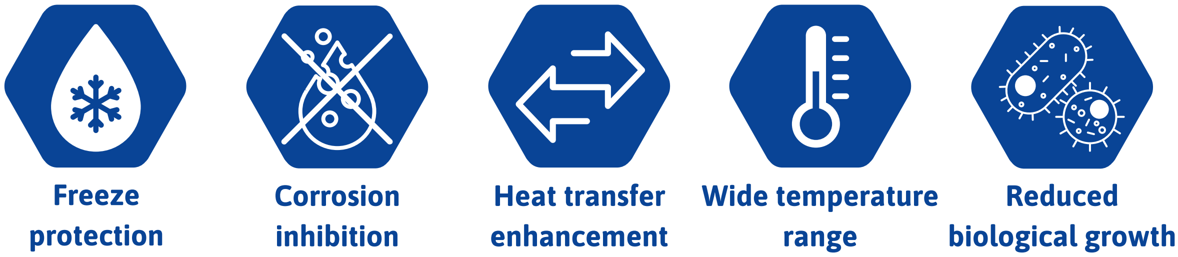
- ***Lower thermal conductivity*:**
  - Compared to some specialised heat transfer fluids, water has lower thermal conductivity. This means that it may require more substantial cooling infrastructure or larger heat exchange surfaces to achieve the desired cooling efficiency.
- ***Corrosion and scaling*:**
  - Water, especially if it is not treated or conditioned properly, can lead to corrosion and scaling issues within the cooling system. These issues can affect the performance and lifespan of components and require additional maintenance and treatment measures.
- ***Freezing point and temperature considerations*:**
  - Water has a relatively high freezing point, which can be a concern in colder environments or during power outages. Special precautions, such as antifreeze additives or heating elements, may be required to prevent freezing.
- ***Electrical conductivity*:**
  - Water is a good conductor of electricity, which can pose risks if there is a leak or spillage near electrical equipment. Adequate insulation and safety measures should be implemented to minimise electrical hazards.
- ***Water damage risk*:**
  - Any leaks or accidental spills of water within the data centre can lead to significant equipment damage and potential downtime. Proper water contaminant and leak detection systems are essential to mitigate these risks.

When considering using water as a heat transfer fluid, it is crucial to carefully assess the specific requirements, environmental conditions, and potential challenges of the data centre to determine if water is the most suitable choice for effective and efficient cooling.

Heat Transfer Fluids Used in Data Centres

Glycol

The use of glycol as a heat transfer fluid in data centre cooling systems can be beneficial for the following reasons:



- ***Freeze protection*:**
  - One of the significant advantages of using glycol is its ability to lower the freezing point of the heat transfer fluid mixture. By adding glycol to water, the resulting mixture has a lower freezing point, reducing the risk of heat transfer fluids freezing in colder environments or during power outages.
- ***Corrosion inhibition*:**
  - Glycol-based heat transfer fluids often contain corrosion inhibitors, which help to protect the cooling system components from corrosion and scale formation. This extends the lifespan of the equipment and reduces maintenance requirements.
- ***Heat transfer enhancement*:**
  - Glycol, especially ethylene glycol, has higher thermal conductivity than water. This can enhance the heat transfer efficiency of the cooling system, allowing for more effective removal of heat from data centre components.
- ***Wide temperature range*:**
  - Glycol-based coolants can operate within a wide temperature range, making them suitable for both low-temperature and high-temperature cooling applications. They can maintain stable performance even in extreme temperature conditions.
- ***Reduced biological growth*:**
  - Glycol-based coolants, particularly those containing biocides, have the ability to suppress biological growth such as algae and bacteria. This helps to maintain the cleanliness and efficiency of the cooling system.

Heat Transfer Fluids Used in Data Centres

Glycol

However, the use of glycol does have some drawbacks to consider:

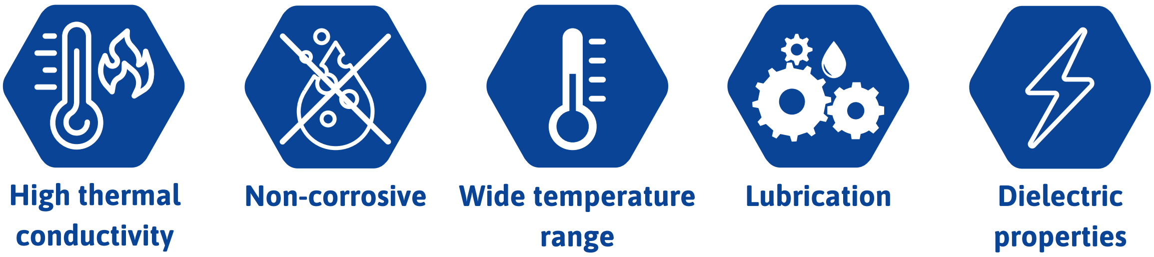
- ***Increased cost*:**
  - Glycol-based heat transfer fluids, especially those with higher concentrations of glycol, can be more expensive than water or other heat transfer fluids. The cost of glycol and additional treatment additives should be considered when assessing the overall cooling system budget.
- ***Lower heat capacity*:**
  - Compared to water, glycol has a lower heat capacity, which means that it can hold less heat per unit volume. This may require larger cooling infrastructures or more substantial heat exchange surfaces to achieve the desired cooling efficiency.
- ***Viscosity*:**
  - Glycol-based heat transfer fluids tend to have higher viscosity than water. This can increase pumping requirements and put additional strain on the cooling system's pumps and pipes.
- ***Reduced heat transfer efficiency*:**
  - While glycol can enhance heat transfer compared to water, it may still have lower thermal conductivity than some specialised heat transfer fluids. This could impact the overall cooling efficiency and effectiveness, particularly in high-performance data centres.
- ***Environmental considerations*:**
  - Glycol, especially ethylene glycol, is toxic and can be harmful to humans and the environment. Proper handling, disposal, and adherence to safety protocols are necessary to mitigate potential risks.

When considering the use of glycol as a heat transfer fluid, it is essential to weigh the benefits or freeze protection and corrosion inhibition against the increased cost and potential trade-offs in heat transfer efficiency. It's important to assess the specific requirements, temperature conditions, and environmental considerations of the data centre to determine if glycol is the most suitable choice for the cooling system.

Heat Transfer Fluids Used in Data Centres

Oil

Using oils as heat transfer fluids, particularly in the context of data centre liquid cooling, has both advantages and disadvantages. The advantages are as follows:



- ***High thermal conductivity*:**
    - Oils generally have higher thermal conductivity than water or air; allowing them to efficiently absorb and transfer heat away from the equipment. This can result in more effective cooling of data centre components.
- ***Non-corrosive*:**
    - Many oils used as heat transfer fluids have non-corrosive properties, which helps to protect the components and infrastructure of the cooling system. It reduces the risk of corrosion-related damage to equipment, such as pipes, pumps, and heat exchangers.
- ***Wide temperature range*:**
    - Oils can operate within a wide temperature range, making them suitable for both low-temperature and high-temperature cooling applications. They can maintain a stable performance even in extreme temperature conditions.
- ***Lubrication*:**
    - Oils can provide lubrication to moving parts within the cooling system, such as pumps or valves, reducing friction and wear. This can enhance the longevity and efficiency of the system.
- ***Dielectric properties*:**
    - Some oils have good electrical insulation properties, meaning that they can be used in situations where electrical components are in close proximity to the cooling system. This reduces the risk of electrical short circuits and other related hazards.

Heat Transfer Fluids Used in Data Centres

Oil

The disadvantages to using oil as a heat transfer fluid are:

- ***Flammability***:
  - Oils used as heat transfer fluids can be flammable or combustible, posing a fire hazard if not handled properly. Special precautions, such as fire suppression systems and proper safety protocols, must be in place to mitigate the risk.
- ***Environmental impact***:
  - Some oils may have environmental concerns, especially if they contain toxic or environmentally harmful substances. Proper disposal and contaminant measures should be followed to minimize any negative impact on the environment.
- ***Cost***:
  - Oils can be more expensive than other heat transfer fluids like water. They may require additional filtration or purification processes to maintain their performance, adding to the overall cost.
- ***Maintenance and clean-up***:
  - Oils may require regular maintenance, including monitoring and replacing contaminated or degraded fluid. In the event of leaks or spills, oil clean-up can be more challenging and time-consuming compared to other fluids.
- ***Compatibility***:
  - Oils may not be compatible with all materials or components in the cooling system. It's essential that the selected oil is compatible with the seals, gaskets, and other materials used in the system to prevent damage or leakage.

Overall, while oils offer advantages such as high thermal conductivity and non-corrosive properties, their flammability, potential environmental impact, and maintenance requirements, should be carefully considered before implementing them as a heat transfer fluid in data centre cooling systems.

When making a decision, it is essential to evaluate specific data centre requirements, such as temperature ranges, equipment compatibility, safety concerns, and budget constraints. Additionally, factors like cooling efficiency, maintenance needs, environmental impact, and overall system reliability should be considered.

Ultimately, selecting the most suitable heat transfer fluid involves finding the right balance between performance, cost, safety, and environmental considerations. Consulting with experts and conducting thorough evaluations will help ensure an optimal heat transfer fluid choice for data centre cooling systems, promoting efficiency, reliability, and sustainability.

Control Methods

Recirculating chillers used in data centres are typically equipped with a variety of control methods to ensure optimal performance and reliability. Some of the common control methods used in these systems include:

Proportional Fan Speed Control:

- Proportional fan speed controls adjust fan speed based on the cooling demand. Slower fan speeds during lower cooling demand result in energy savings and quieter operation. These controls are suitable for data centres with varying cooling requirements. They provide energy efficiency, extended equipment life, reduced noise levels, and stable operation.

On/Off Fan Controls:

- On/off fan controls simply turn fans on when cooling is needed, and off when not needed. They are straightforward and cost-effective. This control method is suitable for scenarios with relatively stable cooling demands. However, on/off cycling can cause more wear on components and lead to less precise control.

PID/Hot Gas Bypass Control:

- This is standard on all units, excluding the A-Series. Proportional-Integral-Derivative (PID) control, and hot gas bypass systems are more advanced methods. PID control adjusts cooling capacity based on temperature variations, ensuring precise temperature control. Hot gas bypass systems maintain constant evaporator temperature during low load conditions. These controls are valuable for data centres where precise temperature control is crucial. They optimise energy usage and maintain stable cooling, but implementation and maintenance might be more complex.

Continuous Operation Fan Control:

- This is a standard feature on all units in the A-Series. Keeping fans always on provides consistent cooling airflow, simplifies control systems, and eliminates the wear and tear associated with frequent on/off cycling. This approach could be beneficial in data centres with critical cooling requirements, where stable and reliable cooling is a priority. However, it might result in higher energy consumption compared to proportional controls.

Inline Deionisers:

- Inline deionisers are used to remove ions and impurities from cooling water. This helps to maintain the water's purity and prevent scale build up on heat exchange surfaces. Inline deionisers can be particularly valuable in data centres where water quality is essential to prevent corrosion and fouling. Inline deionisers improve equipment longevity, maintain optimal heat transfer efficiency, and reduce the risk of system failures.

When considering the control methods for process cooling equipment in data centres, it's important to assess the specific needs of the facility. A combination of these methods might provide the best solution, as different areas of a data centre might have varying cooling requirements and environmental conditions. This mix of control methods allows data centre operations to tailor cooling strategies for optimal performance, energy efficiency, and equipment protection.