APPLICATION SERIES

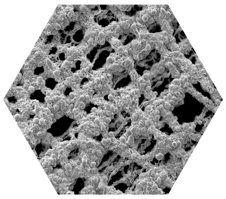
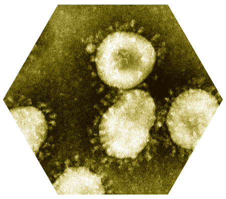
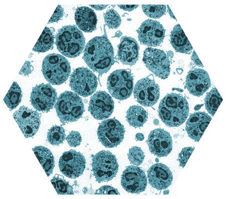
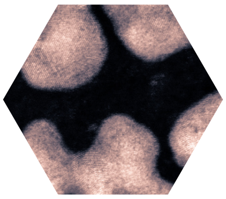
PROCESS COOLING AND ELECTRON MICROSCOPY

Electron microscopy uses a beam of electrons to illuminate a specimen, producing a highly detailed image with a much higher resolution than can be achieved with light microscopy.

Electron microscopes use electromagnetic lenses to focus the beam of electrons onto the specimen, and detectors to capture the electrons that have passed through or scattered off the specimen. By manipulating the beam of electrons and detectors, electron microscopes can produce images of the specimen at different magnifications and with different contrast and resolution.

Electron microscopy is a powerful tool for studying the structure and composition of materials including biological specimens, cells, tissues, and nanomaterials. It has applications in a wide range of fields including materials science, biology, physics, and chemistry.

During operation, electron microscopes generate a significant amount of heat, which can lead to sample damage and reduced image quality. Therefore, it is important to have a process cooling system in place to maintain temperatures.

Electron Microscopy and Process Cooling

Recirculating chillers, also known as closed-loop chillers, are commonly used to cool the microscope column and other components by circulating a heat transfer fluid through a closed loop to remove heat from the equipment.

There are different types of recirculating chillers available, including air-cooled and water-cooled systems. Air-cooled chillers use fans to dissipate the heat from the heat transfer fluid, while water-cooled chillers use a heat exchanger to transfer the heat to a primary water circuit that is then cooled by another chiller, or cooling tower.

The choice of chiller depends on the specific requirements of the electron microscope and the laboratory environment.

Air-Cooled Chillers

The main advantage of air-cooled chillers is that they do not require a separate water circuit or a cooling tower, which can make them easier to install and maintain.

However, one of the main limitations of air-cooled chillers is that they are less efficient than water-cooled systems, especially in hot and humid environments. This can lead to increased energy consumption and reduced cooling capacity, which can affect the stability of the electron microscope and the quality of the images.

To overcome these limitations, it is important to ensure that the air-cooled chiller is properly sized for the heat load generated by the electron microscope and other equipment in the laboratory. This will help to ensure that the chiller can provide adequate cooling, even in hot and humid environments.

It is also important to ensure that the air-cooled chiller is properly maintained to prevent the accumulation of dust and other debris on the heat exchanger and fan, which can reduce the efficiency of the cooling system. Regular cleaning and maintenance can help to ensure that the chiller operates at peak efficiency and provides consistent cooling for the electron microscope.

Electron Microscopy and Process Cooling

Air-Cooled Chillers

Air-cooled chillers have several benefits when used with electron microscopy:

Easier installation | **Low maintenance requirements** | **Reduced water usage**

- ***Easier installation***:
  - Air-cooled chillers do not require a separate water circuit or cooling tower, which can make them easier to install in laboratory spaces where water resources are limited or where plumbing is difficult to install.
- ***Lower maintenance requirements***:
  - Air-cooled chillers have fewer components than water-cooled chillers, which can lead to lower maintenance requirements and lower maintenance costs over the lifetime of the equipment.
- ***Reduced water usage***:
  - Air-cooled chillers do not require a continuous water supply, which can help to conserve water resources and reduce the environmental impact of laboratory operations.

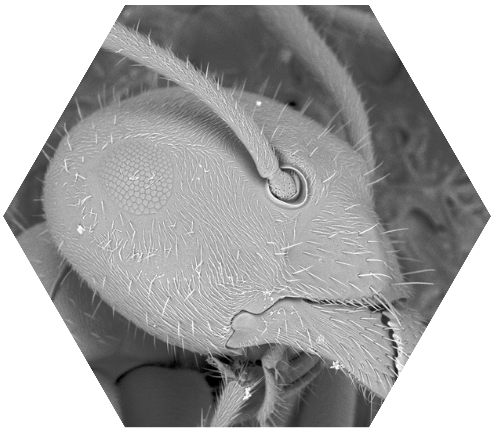
Electron Microscopy and Process Cooling

Air-Cooled Chillers

While air-cooled chillers offer several benefits when used in electron microscopy, there are also some drawbacks to consider:

- ***Reduced cooling efficiency*:**
  - Air-cooled chillers may have reduced cooling efficiency compared to water-cooled chillers, especially in hot and humid environments. This can lead to reduced stability of the electron microscope and reduced image quality.
- ***Higher ambient noise levels*:**
  - Air-cooled chillers generate noise due to the operation of their fans. This can be a concern in laboratory spaces where low ambient noise levels are required, such as microscopy labs that require quiet conditions for optimal imaging.
- ***Dissipation of heat into the air*:**
  - Air-cooled units dissipate heat into the surrounding environment, which can increase the temperature of laboratories and working spaces. This may mean that it is necessary to upgrade air conditioning within the building.
- ***Vibration/turbulence*:**
  - As air-cooled units dissipate heat into the environment using a fan, air vibration/turbulence may be added to the room. Upgrades to the building's air conditioning may also add to this. The effects of this can be minimised by the installation of specialised heat exchanger panels for electron microscopy suites.
- ***Potential for increased energy consumption*:**
  - Air-cooled chillers may require more energy to operate than water-cooled chillers, as they rely on fans to dissipate heat. This can lead to increased energy consumption and operating costs over time.

It is important to carefully consider the specific requirements of the laboratory and the electron microscope when selecting a cooling system, and to weigh the benefits and drawbacks of air-cooled chillers against other available options.



Electron Microscopy and Process Cooling

Water-Cooled Chillers

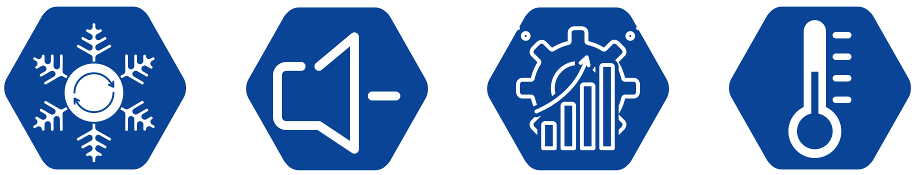
Water-cooled chillers work with electron microscopes by circulating a heat transfer fluid through a closed loop that is then cooled by a heat exchanger and a cooling tower or other means of heat dissipation.

The heat transfer fluid is circulated through the chiller unit and into the electron microscope. The heat transfer fluid absorbs heat from the microscope and other laboratory equipment and is then returned to the chiller unit for cooling.

In the chiller unit, the coolant is cooled by a heat exchanger, which transfers heat into a primary water circuit. The heated water is then sent to a cooling tower or other means of heat dissipation, where it is cooled. The cooled water is then returned to the chiller unit to repeat the cooling cycle.

Water-cooled chillers can provide more precise temperature control and higher cooling capacity compared to air-cooled chillers but require additional plumbing and a cooling tower or other means of heat dissipation and may have higher maintenance requirements and water quality concerns.

Water-cooled chillers offer several advantages when used with electron microscopes:



Higher cooling efficiency | **Lower ambient noise levels** | **Higher cooling capacity** | **More precise temperature control**

- ***Higher cooling efficiency*:**
    - Water-cooled chillers can offer higher cooling efficiency compared to air-cooled chillers, especially in hot and humid environments. This can help to maintain the stability of the electron microscope and improve image quality.
- ***Lower ambient noise levels*:**
    - Water-cooled chillers generate less noise than air-cooled chillers, which can be important in laboratory spaces where low ambient noise levels are required.
- ***Higher cooling capacity*:**
    - Water-cooled chillers can handle higher heat loads from electron microscopes and other laboratory equipment, which can make them more flexible and adaptable to changing laboratory environments.
- ***More precise temperature control*:**
    - Water-cooled chillers can provide more precise temperature control over the heat transfer fluid compared to air-cooled chillers, which can be important if the electron microscope requires a specific temperature range to operate optimally.

Electron Microscopy and Process Cooling

Water-Cooled Chillers

However, there are also some drawbacks to using water-cooled chillers with electron microscopes:

- ***Higher installation costs:***
    - Water-cooled chillers require additional plumbing and a cooling tower or other means of heat dissipation, which can make them more expensive to install compared to air-cooled chillers.
- ***Higher maintenance requirements:***
    - Water-cooled chillers have more components compared to air-cooled chillers, which can lead to higher maintenance requirements and higher maintenance costs over time.
- ***Water quality concerns:***
    - Water-cooled chillers require water to operate, which can lead to concerns about water quality and the need for water treatment and filtration.

It is important to carefully consider the specific requirements of the laboratory and the electron microscope when selecting a cooling system, and to weigh the benefits and drawbacks of water-cooled chillers against other available options.

Heat Transfer Fluids

Heat transfer fluids used with electron microscopes are typically liquids that have a high heat capacity, low viscosity, and low freezing point. These properties help to ensure that the heat transfer fluid can efficiently absorb heat from the electron microscope and other laboratory equipment and transfer it to the chiller unit for dissipation.

Some common heat transfer fluids used with electron microscopes include:

- ***Water*:**
  - Water is a commonly used heat transfer fluid due to its high heat capacity and low cost. However, it has a relatively high freezing point, which can limit its use in cold temperature applications.
- ***Ethylene Glycol*:**
  - Ethylene glycol is a widely used heat transfer fluid that has a low freezing point and good heat transfer properties. It is often used in combination with water to improve its heat transfer efficiency.
- ***Propylene Glycol*:**
  - Propylene glycol is similar to ethylene glycol in its properties and is often used as an alternative when the use of ethylene glycol is restricted due to its toxicity.

The choice of heat transfer fluid will depend on a variety of factors, including the operating temperature range, heat load, and other environmental and safety considerations. It is important to select a heat transfer fluid that is compatible with the electron microscope and other laboratory equipment, and to properly maintain and monitor the fluid to ensure optimal performance and safety.

Pump Options

Positive Displacement Pumps

Positive displacement pumps are commonly used in chillers used with electron microscopes to circulate the heat transfer fluid through the cooling system. These pumps have several advantages and disadvantages, which are outlined below:

Advantages of using positive displacement pumps include:

High accuracy and consistency | **High pressure capabilities** | **Higher cooling capacity**

- ***High accuracy and consistency***:
  - Positive displacement pumps deliver a precise and consistent flow of fluid, making them ideal for applications where accurate temperature control is required.
- ***High pressure capabilities***:
  - Positive displacement pumps can generate high pressure, which can be useful for applications where the cooling system needs to operate at a high flow rate or pressure.
- ***Self-priming***:
  - Positive displacement pumps can self-prime, which means that they can start pumping without the need for additional priming or assistance.

Potential drawbacks of the use of positive displacement pumps include:

- ***Maintenance***:
  - Positive displacement pumps require regular maintenance to ensure that they continue to operate at peak efficiency. The seals, bearings, and other components can wear over time and require replacement.
- ***Limited flow rate and pulsing flow***:
  - Positive displacement pumps have a limited flow rate compared to other types of pumps, which can be a disadvantage in applications where high flow rates are required. Due to the operation of positive displacement pumps, fluid is delivered in pulses, which can affect electron microscopes.

Overall, positive displacement pumps can be a good choice for chillers used with electron microscopes because they provide accurate and consistent flow, high pressure capabilities, and self-priming capabilities. However, they can be more expensive than other types of pumps, require regular maintenance, and have a limited flow rate.

Pump Options

Centrifugal Pumps

Centrifugal pumps are also commonly used in chillers used with electron microscopes to circulate heat transfer fluid through the cooling system. The advantages of using a centrifugal pump include:

High flow rate and smooth flow **Low maintenance**

- ***High flow rate and smooth flow*:**
  - Centrifugal pumps can achieve high flow rates, making them ideal for applications where a high volume of heat transfer fluid is required. Centrifugal pumps do not pulse, which can affect the quality of electron microscope imaging.
- ***Low maintenance*:**
  - Centrifugal pumps have fewer moving parts compared to positive displacement pumps, which can reduce maintenance requirements.

Potential drawbacks of the use of centrifugal pumps include:

- ***Lower pressure capabilities*:**
  - Centrifugal pumps have lower pressure capabilities compared to positive displacement pumps, which can be a disadvantage in applications where high pressure is required.
- ***Lower accuracy*:**
  - Centrifugal pumps can be less accurate than positive displacement pumps when it comes to maintaining a consistent flow rate, which can be a disadvantage in applications where precise temperature control is required.
- ***Not self-priming*:**
  - Centrifugal pumps require priming before they can start pumping, which can be a disadvantage in some applications where the pump is located above the fluid level.

Overall, centrifugal pumps can be a good choice for chillers used with electron microscopes because they provide high flow rates, require less maintenance, and are generally less expensive than positive displacement pumps. However, they have lower pressure capabilities, lower accuracy, and require priming before they can start pumping.

The choice of pump will depend on the specific needs of the application and the trade-offs between performance, cost, and maintenance requirements.

Control Methods

Proportional Fan Speed

Chillers used with electron microscopes may have proportional fan speed control to improve their efficiency and reduce noise levels. The fans in a chiller are used to draw air over the condenser, which dissipates heat from the cooling system to the surrounding environment. By adjusting the fan speed to match the cooling load, the chiller can operate more efficiently and with less noise.

Proportional fan speed control allows the fans to operate at a speed that is proportional to the cooling load of the chiller. This means that the fans will run at a higher speed when the cooling load is high, and at a lower speed when the cooling load is low. By adjusting the fan speed in this way, the chiller can maintain a constant temperature and reduce energy consumption.

In addition to improving efficiency, proportional fan speed control can also reduce noise levels. When a chiller is operating at a low cooling load, the fans do not need to run at full speed. By reducing the fan speed, the noise levels of the chiller can be reduced, making it more suitable for use in quiet laboratory environments.

High Ambient Fans

Chillers used with electron microscopes may have high ambient fans to help to maintain their cooling capacity in high temperature environments. When the ambient temperature is high, the heat transfer from the chiller to the environment is less efficient, which can reduce the cooling capacity of the chiller.

High ambient fans are designed to operate at a higher speed than standard fans, allowing them to draw in more air and improve the heat transfer rate. This helps to maintain the cooling capacity of the chiller in high temperature environments and can prevent overheating or damage to the electron microscope or other laboratory equipment.

In addition to improving cooling capacity, high ambient fans can also help to reduce energy consumption. By increasing the fan speed when the ambient temperature is high, the chiller can maintain its cooling capacity without the need for additional energy-intensive cooling methods.

Control Methods

Extra Close Control

Chillers used with electron microscopes may have extra close control to ensure that the cooling system maintains a stable and precise temperature. Electron microscopes require a stable and consistent operating temperature to produce accurate and reliable imaging results. Variations in temperature can cause fluctuations in the electron beam, leading to distortion in the images.

Extra close control involves the use of advanced temperature control systems that can maintain the temperature within a very narrow range. This allows the chiller to maintain a stable temperature, even in the presence of external factors that could cause temperature fluctuations, such as changes in the laboratory environment or changes in the cooling load of the electron microscope.

Remote Alarm Box

Chillers used with electron microscopes may have remote alarm packs to alert laboratory personnel of any issues with the cooling system. Electron microscopes require a stable and consistent operating temperature, and any disruptions to the cooling system can cause fluctuations in temperature that can lead to imaging errors or damage to the equipment.

Remote alarms can alert laboratory personnel to issues with the cooling system, such as temperature or fluid issues. These alarms can be set up to trigger an audible or visual alert in the laboratory.

Remote alarms can help laboratory personnel to respond quickly to issues with the cooling system and prevent any damage or interruptions to the electron microscope. This can help to ensure that the laboratory operates efficiently and that any issues with the cooling system are addressed promptly.

Control Methods

Quick Release Connectors

Chillers used with electron microscopes may have quick release connectors to facilitate the installation and maintenance of the cooling system. Quick release connectors are designed to allow the chiller to be easily connected and disconnected from the electron microscope or other laboratory equipment, without the need for additional tools or complex procedures.

One of the benefits of quick release connectors is that they can save time and effort during the installation and maintenance of the chiller. For example, if the chiller needs to be removed for maintenance or repairs, the quick release connectors can be easily disconnected, allowing the chiller to be quickly removed from the laboratory. Similarly, when a new chiller needs to be installed, the quick release connectors can make the process quicker and easier, since the chiller can be quickly and easily connected to the electron microscope or other equipment.

Another benefit of quick release connectors is that they can help to reduce the risk of leaks or other problems that can occur during the installation or removal of the chiller. By providing a secure and reliable connection, quick release connectors can help to ensure that the chiller operates efficiently and reliably, without any disruptions or malfunctions.

Remote Stop/Start

Chillers used with electron microscopes may have a remote stop/start feature to allow laboratory personnel to control the operation of the cooling system from a remote location. This feature can be particularly useful in large laboratories where the chiller may be in a different room or area from the electron microscope or other laboratory equipment.

Remote stop/start allows laboratory personnel to turn the chiller on or off remotely, without the need to physically access the chiller. This can be useful in situations where the laboratory personnel need to turn off the cooling system quickly, for example, in the event of an emergency or if the electron microscope is not in use.

In addition to providing greater convenience, remote stop/start can also help to improve the efficiency of the laboratory. By allowing laboratory personnel to control the chiller from a remote location, they can avoid the need to travel to the chiller to turn it on or off, saving time and reducing the risk of disruptions to the laboratory workflow.

Control Methods

Weatherproofing

Chillers used in electron microscopy laboratories may be weatherproofed for several reasons.

Electron microscopes are highly sensitive instruments that require a stable environment to produce accurate and high-resolution images. Air movement, such as drafts caused by wind or air conditioning systems, can introduce vibrations and perturbations that can affect the stability and performance of the electron microscope. Weatherproofing the chiller means that it can be housed outside, minimising the impact of air movement, ensuring a more stable environment for the microscope.

Electron microscopy laboratories are very equipment-heavy, and often have limited available space. Weatherproofing the chiller allows it to be installed outdoors, or in areas where protection from the elements is necessary, freeing up valuable indoor space for other equipment or operations. Weatherproofing helps to shield the chiller from the elements, reducing the risk of water damage, dust accumulation, and other potential issues that can affect the performance and longevity of the cooling system.

By weatherproofing the chiller, it becomes more resilient to external factors, providing a stable and protected cooling solution for the electron microscope. This helps to ensure optimal performance and accuracy in electron microscopy while addressing the space constraints and minimising the impact of air movement that can interfere with the delicate imaging process.