Realizing Chillers' Capabilities in Laboratories

Chillers offer an alternative to using tap water in laboratory applications. Do they meet your testing needs?

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Liquid temperature control is a critical component in laboratories. Before the advent of chillers, scientists typically used tap water, dry ice and liquid nitrogen for temperature control and to cool analytical instrumentation and condensers. But, with the rising cost of tap water, regional restrictions on tap water usage and the need for tighter stability with today's sophisticated equipment, chillers have become a necessity. Additionally, tap water may contain harmful particulates that can build up in an instrument's cooling lines. This can cause equipment failure, leading to expensive repair costs.

A chiller is a refrigerated re-circulating liquid cooling system consisting of a compressor, condenser, evaporator, pump and temperature controller. The chiller recirculates temperature-controlled fluid to the application to remove heat. The heat is picked up by the recirculating fluid and is returned to the chiller. The chiller cools the fluid to the setpoint specified by the user and then is recirculated back to the application.

A chiller regulates temperature by compressor cycling, heater cycling or hot-gas bypass. Compressor cycling entails turning the compressor on and off continually to maintain setpoint. This can be acceptable for an application that does not require tight temperature control such as chilled water for building air conditioning. For laboratory applications, however, temperature stability is crucial. Continual compressor cycling will cause premature wear and failure; a compressor will last longer if it is run constantly. Heater cycling and hot-gas bypass both allow continuous operation. In the heater cycling method, a heater fights against the constant refrigeration to maintain the setpoint. While this provides stability, it also results in higher power consumption, adding unnecessarily to the cost of ownership.

Hot-gas bypass can provide stable fluid temperatures without increasing power consumption. Extremely cold liquid refrigerant cools the recirculating fluid via a coil in the fluid reservoir or through a heat exchanger. As the refrigerant removes heat from the recirculating fluid, it changes state to a hot gas. If the fluid requires more cooling, the hot gas is sent to the compressor and condenser to return to a cold liquid state. If the fluid must be heated, the hot gas is routed back directly to the coil or heat exchanger by a solenoid. Running the compressor continually ensures the chiller will be more reliable and have a longer life.

Once heat is removed from an application, the chiller must remove its own waste heat. This can be done by rejecting the heat into the air (air-cooled condenser) or to a secondary water source (water-cooled condenser). Which version to use depends on where the chiller will be placed. If the room is large and the chiller is small, heat rejection into the ambient air will not be a problem. If the room is small and the chiller is relatively large, a water-cooled condenser might be an alternative. A water-cooled condenser requires a secondary water source be circulated to the chiller. This typically is tap water, building chilled water or tower water. Most laboratories will have many applications that require liquid temperature control. Some applications need only cold water, and it can vary in temperature by as much as a few degrees. Other applications such as lasers, spectrophotometers, inductively coupled mass spectrometers (ICP/MS), atomic absorption graphite furnaces (AAGF), electrophoresis, gas chromatograph mass spectrometers (GC/MS) and electron microscopes need a higher degree of temperature stability.

To size a chiller for a specific application, one must know the heat removal requirement, temperature, fluid flow and fluid pressure. In many cases, these requirements can be obtained from the instrument manufacturer. If this information is not known, a

Closed loop recirculating chillers ensure particulate-free fluid for laboratory liquid cooling applications.

Table 1. Heat Load Calculation

Flow Rate (gal/hour) x Cooling Fluid Weight (lb/gal) x Specific Heat of Cooling Fluid x ΔT°F (Temperature Out - Temperature In) = Heat Load (BTU/hr)

Note: Weight of water/gal = 8.35 lb/gal; Specific heat of water = 1; 12,000 BTU/hr = 1 ton; 1 W = 3.41 BTU/hr

When plugged into a heat load calculation, the flow rate of water entering an application and the incoming and exiting water temperatures determine the amount of heat contained in cooling water.

heat load calculation can be performed (table 1). When the application is running and being cooled properly, measure the incoming and exiting water temperature. Also, measure the flow rate of the water entering the application. If a flow meter is not available, use a 5-gal bucket and a stop watch. Enter these three numbers into the formula to determine the amount of heat contained in the cooling water. This is how much heat the chiller needs to remove.

Recirculating Fluid

In laboratory applications, cooling condensers and evaporators typically necessitate cold fluid recirculation. Tap water can be used as long as it is cold enough to condense or evaporate the material from solution. A common working temperature is 39°F (4°C), which is colder than what is commonly available from tap water. Fluid temperature stability usually is not critical, but fluid pressure is when the condenser or evaporator is made of glass. Glass can withstand fluid pressures up to 25 psi. Therefore, when choosing a chiller for this type of application, look for a unit with a centrifugal pump (low pressure). If a centrifugal pump is not available and a positive-displacement or turbine (high pressure) pump is used, an internal or external pressure reducer should be used to reduce the fluid pressure so the glassware is not damaged.

Another laboratory application is diffusion pumps, which require a high pressure pump because they employ small cooling lines. Similar to condensers and evaporators, temperature stability is not extremely important. In laboratory applications, diffusion pumps are used in electron microscopes.

Conversely, there are many laboratory cooling applications where fluid temperature stability is critical. For lasers, a consistent day-to-day temperature will ensure a coherent beam as well as repeatable results. Commonly cooled components include the laser tube or laser diode, depending on the type of laser.

Refrigerated bath/circulators provide temperature stability for calibraion applications and have circulating pumps for instrumentation cooling.

A number of analytical instruments are used in laboratories for analysis and identification of compounds in a sample. The majority require water cooling at precise temperatures. ICP/MS is an analysis method where the sample is introduced into an argon plasma heated to 13,940°F (8,000°K) by a radio frequency source. Each element in the sample then produces a characteristic emission spectrum, and a chiller is used to cool the torch that heats the sample. GC/MS also identifies unknown compounds in a sample. The diffusion pump requires cooling, if present. An AAGF is used to quantitatively define up to 60 elements in a sample. The process uses automation (by a flame or electric heat source) to create a vapor that is interposed into the light path. The chiller cools the torch or the graphite furnace.

A multitude of water cooling applications exist in a laboratory. A refrigerated, recirculating chiller is a suitable replacement for tap, tower or building chilled water. The recirculating chiller fluid is stable in temperature, flow and pressure, and the closed-loop recirculating system will ensure that the fluid is clean and free of particulate matter.

A refrigerated, recirculating chiller provides a suitable replacement for tap water.

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