Chillers 101

This month, HVAC&R Nation dissects the world of chillers with the help of Simon Ho from Heatcraft and John Wisdom from Powerpax. From their function and application in air conditioning through to servicing, chillers play a vital role in whole-of-system efficiency.

Rooftop chiller

Put simply, a chiller is a device which cools a fluid by removing heat from it, either through a vapour – compression or absorption refrigeration cycle; with the key components being the compressor, condenser, evaporator and expansion device.

Most typically, the fluid used in chillers is water, which can sometimes be treated with anti-freeze to prevent it from freezing in low temperature applications. Once chilled, this water is then used to cool and dehumidify air in a range of applications, from office buildings and shopping centres, to laboratories and manufacturing facilities.

The chiller takes the heat from the water, at the evaporator, and in doing so lowers its temperature before rejecting it via the condenser. This method of moving the heat from the chiller's evaporator to its condenser is refrigeration – which can be electric driven using compressors or achieved via absorption which is achieved through a heat source such as steam, hot water or another indirect source.

Which chiller?

According to Simon Ho, senior category manager at Heatcraft, the use of a chiller is tied to the choice of using a chilled water system for the air conditioning described earlier, or a direct expansion (DX) system (split systems).

"There are many reasons and applications where a chilled water system is chosen over a DX system but some of the main reasons are the need for large cooling capacities, the need to transport heat over long distances (particularly in large or tall buildings), energy efficiency and the benefit of refrigerant containment in a plant room," he explains.

"Chillers are typically classified in terms of the type of compressor used and also its heat rejection method."

In Australia, the vast majority of chillers use either scroll or screw type compressors while the centrifugal type is most often used where large capacity or high efficiency is required.

Ho says there are many older chillers still operating which use reciprocating compressors. However, these have been superseded due to the new designs in scroll and screw compressors, which yield better efficiencies and reliability.

Most chillers are electric driven, with a small number absorption based, taking advantage of waste heat available.

Selecting a condenser

A condenser can be either water-cooled, air-cooled or the more recently accepted hybrid cooled, which combines water with an air-cooled system.

"In a water-cooled condenser, water is pumped to a cooling tower where the heat is finally rejected to the atmosphere, (but) in some cases the condenser water can be pumped to another location for final heat rejection," explains John Wisdom, sales manager with Powerpax.

Simon Ho

Where an air-cooled condenser is used, the heat is rejected via a heat exchanger using fans. Heat exchangers are finned with tubes containing the heated fluid, and as the fans draw air through the fins the heat is transferred to the atmosphere.

Similarly, a hybrid condenser is essentially an air-cooled condenser with a controlled amount of water sprayed onto its cooling pads to provide a measure of pre-cooling.

"This method enhances the performance of an air-cooled heat exchanger and increases its efficiency," adds Wisdom, who has combined the company's Turbocor chillers with hybrid condensers on a number of successful projects.

According to Ho, air-cooled is the most commonly used in Australia, although they are typically smaller in capacity (less than 1500kW) than water-cooled.

"Water-cooled systems are typically connected to a cooling tower for heat rejection and their capacity can go up to thousands of kilowatts per unit."

For which application?

As described earlier, chillers are largely used for air conditioning, which includes comfort and controlled process applications.

"Typical comfort air conditioning applications are in larger buildings where the capacities are bigger such as office buildings, shopping centres, hospitals, universities and schools," says Wisdom.

"Process air conditioning is where close control of temperature and humidity is required. These sometimes require simultaneous cooling and reheat; and include laboratories, computer rooms, operating theatres and critical manufacturing environments. Process cooling applications also include any manufacturing process where heat generated needs to be rejected. These typically include plastics, food and many other manufacturing processes."

Comparing efficiency

Chiller efficiency is measured as a ratio between the cooling capacity and its power input, and is typically described as a Coefficient of Performance (COP). The higher the COP, the more efficient it is.

However, some parts of the industry also described chiller efficiency in reverse; that is, the ratio of power input to its cooling capacity (kWe/kWr). In this case the smaller the number the better the efficiency.

Chiller

According to Wisdom, electric driven chillers vary in efficiencies depending on the type of refrigerant or compressor used. He says many of the older refrigerants were more efficient than those now replacing them.

"The advent of new refrigerants sparked a whole new wave of development in refrigeration compressor development, to recover efficiencies lost with the new refrigerants and also to keep up with the increasing cost of energy due to Global Warming Potential (GWP)," he says.

"Reciprocating compressors are now almost extinct in new equipment and the focus is now on scroll, screw and centrifugal compression with variable speed drives to compliment them."

These compressors have different limits on available sizes, with scrolls being the lowest, followed by screws and then centrifugals – with efficiency capabilities being in the same order.

"From this, it is correct to assume that smaller chillers are less efficient than larger ones, and this is reflected in the capacity grading of COPs required in the new MEPS for chillers," he adds.

The recent development of oil-free centrifugal compressors, where magnetic bearings (and soon, ceramic bearings) replace the use of oil for lubrication has seen even greater increases in efficiency and lower operating costs.

While it is true that the chiller is one of the largest energy consumers in a building, its efficiency can be masked by how it is run in the chilled water system and the ancillaries attached to it, such as pumps, controls and cooling towers, says Ho.

"In many cases an efficient chiller will mean little in an inefficient chilled water system design or operation. Much of the chiller efficiency numbers quoted by the industry has limited bearing on the actual efficiency being achieved in the field."

Ho says estimating overall chilled water plant efficiency is a complex exercise involving the configuration and design of the plant and its operation, which is something that cannot be done in simple and single chiller efficiency numbers.

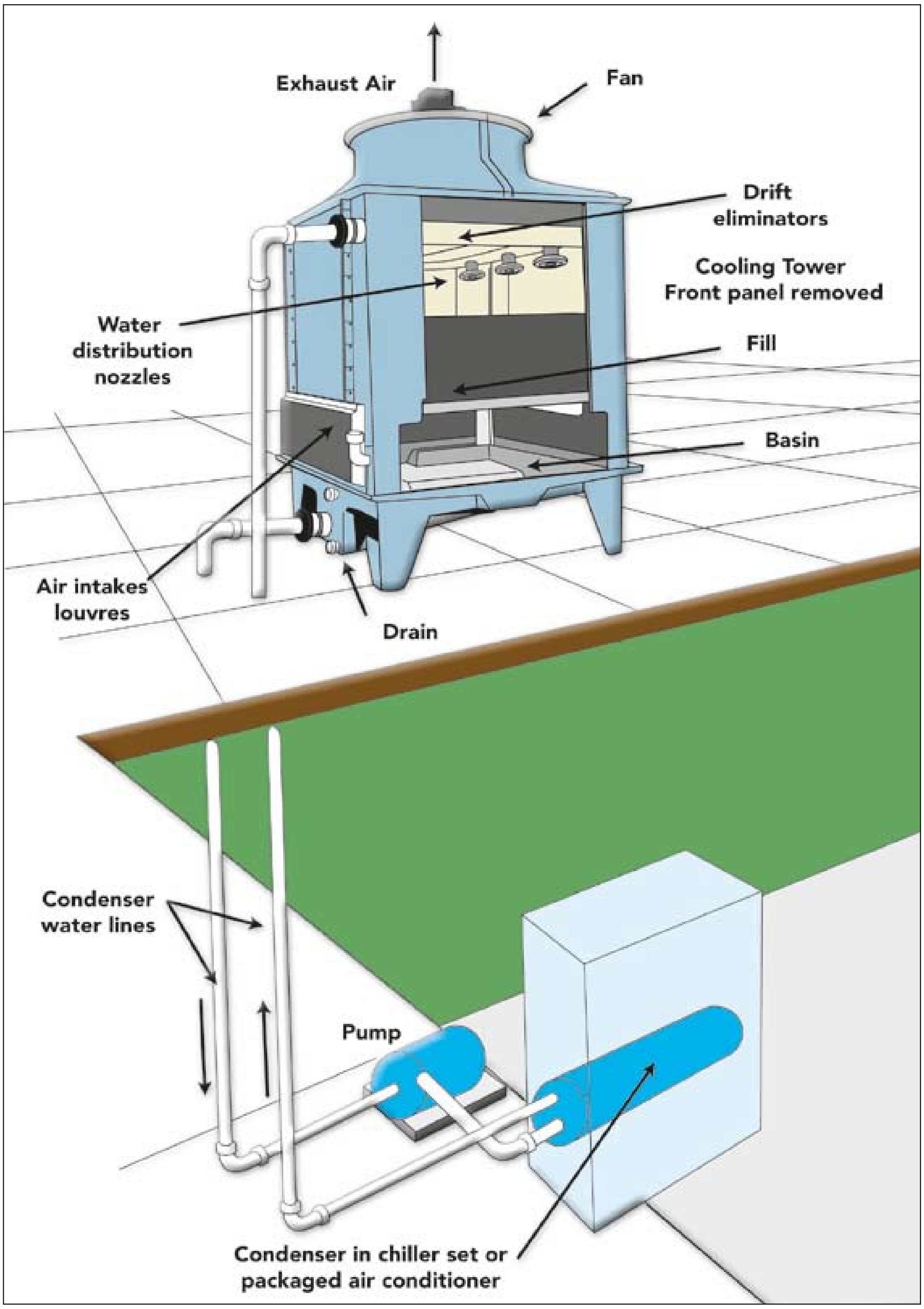
While it may seem logical to use a single large chiller to achieve higher efficiency, in large installations best practice is to use multiple chiller units, some of which may be selected to suit varying load conditions; as this provides a level of redundancy in large installations.

MEPS for chillers

As of July 1, air and water cooled water chillers with a capacity of 350kw and above that operate with a vapour compression cycle will be regulated by Minimum Energy Performance Standards (MEPS).

The MEPS program sets out minimum efficiency levels and are made mandatory in Australia by state government legislation and regulations which give force to the relevant Australian Standards.

For more information on the July 1 introduction of MEPS for chillers, visit www.energyrating.gov.au



Simple chiller schematic

Another option is to use a single large chiller with multiple compressors, which again can provide a level of redundancy in the system.

This consideration becomes even more important in critical applications such as data centres where a break-down in the chiller serving the air conditioning system would spell dire consequences.

Chiller versus DX (split system)

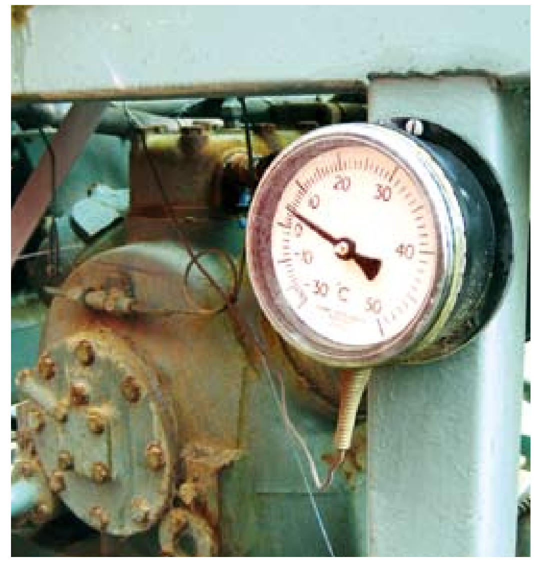
According to Ho, a DX system or multiple units of split systems will always be a cheaper purchase option than a chilled water system. However, as the building size increases, the distances required to pump refrigerant between the split units becomes impractical and inefficient.

"This is when pumping chilled water from a central plant room becomes attractive, but there are other considerations too such as the provision of outside air in the building where this is easily accomplished in a central air handling unit plant."

Furthermore, there is little loss of performance due to long or vertical pipe runs in a chilled water system like there is with multiple split systems, while maintenance is reduced to single unit often in a plant room rather than multiple units spread across the site.

When it comes to servicing, again most work with chillers and associated ancillaries is generally confined to the plant room.

"Typically, chillers require quarterly maintenance with an annual service which will include condenser tube clean for water-cooled chillers. A DX system on the other hand may have numerous outdoor units located in various areas with their indoor units also in various locations. As such, servicing numerous DX units may take longer than chilled water systems, especially in large installations," explains Ho.



Chiller guage

Fault finding can also be tedious and labour intensive, with DX systems given the amount of largely inaccessible refrigerant pipe work running between the two halves of each system.

Another consideration is the safety of occupants where large refrigerant charges can pose a higher risk of leakage and exposure than a chiller system tucked away in a plant room.

Refrigerant charge and safety

The location of a chiller in a plant room ensures two things – ease of service access and refrigerant containment.

As chillers can have as little as 20kg to as much as 1000kg of refrigerant charge in each unit, their location in a plant room reduces the risk of direct contact of the refrigerant with building occupants in the event of a leak or spill.

Such a loss of charge would not only have life threatening consequences to building occupants, but the environmental impact would be significant depending on the refrigerant type.

Furthermore, water-cooled chillers are not designed for outdoor installation and as such, their location in a plant room is critical.

"Chillers located in plant rooms are nearly always water cooled, thus providing higher efficiency compared to conventional externally located air cooled chillers. Sound levels to neighbouring properties are also more easily managed with plant room installation," says Wisdom.

When managing refrigerant containment with chillers, the best place to start is AS/NZ1677.2: 1998. This standard recommends a refrigerant monitor for chiller plant rooms to detect leaks, which should be fixed quickly when detected.

However, Wisdom says automatic leak detection on an external air-cooled chiller is impossible due to the naturally ventilated situation. While refrigerant is a heavy vapour, only close manual leak detection will locate a leak on an outside chiller.

Where older chillers are still in operation, Ho says there are a few things to be mindful of.

"Old purges for low pressure chillers may need to be upgraded to newer, higher efficiency ones to reduce refrigerant emitted during the purge process, while open drive chillers which have a drive shaft seal often need maintenance as old seals are a source of refrigerant leaks." ▲